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# The Canadian Entomologist

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# The Canadian Entomologist

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# The Canadian Entomologist

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No. 10

## The Biology of *Adelges cooleyi* (Gill.) (Homoptera: Phylloxeridae<sup>1</sup>)

By MARGARET E. P. CUMMING<sup>2</sup>

### Introduction

*Adelges cooleyi* (Gill.) causes galls on spruce in the forests and on shelter-belt and shade-tree plantings in Alberta. The alternate host is Douglas fir, on which the injury is less conspicuous. The tree species affected are white spruce, *Picea glauca* (Moench) Voss, Engelmann spruce, *P. engelmanni* Parry, and blue Douglas fir, *Pseudotsuga menziesii* (Mirb.) Franco. *A. cooleyi* is indigenous to North America.

Gillette (10) described this species in 1907, naming the generations on spruce *Chermes cooleyi* and those on Douglas fir, *C. cooleyi* var. *coweni*, although he was aware that the winged adults from each host moved to the other. Chrystal (6) (7) studied the species in British Columbia and in Britain where it was introduced. Annand (1) changed the name of the subfamily from Chermisinae to Adelginae, because the genus *Chermes* L., had been used previously for a group of psyllids. He suggested that there should be only two genera, *Pineus* Shim. and *Adelges* Vallot, in the subfamily. Cameron (4) (5) has studied the species in Britain since that time, and many workers in Europe have described its introduction from North America and have given some information on its life history. Most North-American and British workers have referred this species to the genus *Adelges* since Annand's work was published, but workers in continental Europe and elsewhere prefer to split *Adelges* into several genera. Boerner (3) lists *A. cooleyi* under *Gilletteella* C.B. in his 1952 work, where it is the only species in that genus.

The information presented here was obtained at the Kananaskis Forest Experiment Station, on the eastern slopes of the Rocky Mountains, in 1955, 1956, and 1957. The elevation is 4500 feet, so that development is later in the season than in many lower areas where the species occurs. The complete polymorphic cycle was observed. The terminology used to describe the generations is that proposed by Marchal (11) and adopted by Annand (1). Although *A. cooleyi* takes two years to complete a cycle on spruce and Douglas fir, all the generations are present in any one year.

Standard methods were used: tagging of twigs for regular examination, caging of twigs for transfer of winged specimens, and preparation of slides for microscopic examination. Twigs were brought indoors to rear the sexuales generation. For some generations the number of instars was confirmed by measuring the whip of the antenna; at a magnification of 240 the measurements fell into distinguishable groups. Observation of the moults of one individual often assisted in the grouping.

### Life-History and Habits

#### Fundatrix

The fundatrices are the progeny of the sexuales. The eggs deposited by the sexuales at the nodes of spruce in the fall hatch in three to four weeks. (Inside rearing provided an opportunity to watch the incubation period closely. Nine eggs hatched in an average of 21.3 days; the range was 16 to 28. Observations suggested that the incubation period is longer in the field.) The

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nymphs move to the upper surfaces of the needles to feed and they may overwinter there but they usually settle on the stem immediately below the buds, seldom more than one inch below them, on the underside of the branch. Once settled, they remain in approximately the same position.

The fundatrices are reported to have three nymphal instars. Most fundatrices examined had only two exuviae behind them, but one was found with three. The second and third moults were very similar and it is not known whether three moults is the usual number and one moult is usually lost, or whether two moults are common in this area. The nymphal stages are present for a relatively short time in the spring. The first-instar nymphs are a dark-brown colour with a green tinge, but appear black when seen on the needles. There are heavily sclerotized plates on the head and thorax and a fringe of white wax, which is secreted by the lateral glands, surrounds them. The pleural and mesial glands produce a fine powdery wax which surrounds each gland area. The second-instar nymphs resemble the adults in general appearance but have a thinner and more delicate cuticle. They produce wax strands which form flocculent coverings over their bodies. The adults are dark brown shaded with green; wax covers their bodies and protects the eggs.

The fundatrices or stem mothers are parthenogenetic and are the most prolific of all the generations. The largest number of eggs counted was 352; other counts were 90 and 119. Observations suggest that about 200 is the usual number. One female was observed ovipositing and it was seen that the wax thread was attached to the egg before it was extruded and the abdomen near the ovipositor was folded in around the egg covering it with a fine wax powder.

#### *Gallicola Migrants*

The gallicolae migrantes, which are the progeny of the fundatrices, are the gall-forming, summer generation on spruce. They hatch about two weeks after the eggs are deposited and move to the new growth, which is usually just beginning to elongate.



Fig. 1. a, Young gall of *A. cooleyi* on spruce. b, Opened gall.



The galls are formed by the swelling of the stems and of the needle stalklets (Fig. 1a, 1b). The chambers of the gall are formed at the bases of the needles; lateral joining of the tissue encloses the chambers; the lips of the chambers are at the junction of the tissue from adjacent needles. Each chamber remains separate, and may be exposed by pulling the needle away from the stem. Gall development is completed in a few days. In some adelgine galls, needle elongation is retarded, but in *A. cooleyi* the needles from the gall appear to attain normal length. The number of chambers in a gall varies; two one-sided galls had 10 and 15 chambers; one gall completely surrounding a twig had 27 chambers. The number of nymphs in a chamber varied from 0 to 30. The nymphs were settled with their mouth-parts inserted either into the stem or into the needle bases. One-sided galls cause the twig tips to bend and the tip usually dies as a result of the gall formation. Young galls are green, shaded with pink or purple, and old galls are brown and dry.

Conclusive evidence that the feeding of the stem mother is essential to gall formation was obtained. Egg masses of fundatrices were carefully removed and placed on other twigs where no fundatrices had been. The fundatrices were identified from slide mounts. Ten twigs on which egg masses were placed produced no galls. Hatching occurred and dead nymphs were found on the needles; most of the nymphs must have died and dropped off. Four partially formed galls developed on the twigs from which the fundatrices and egg masses were removed. (Three of these were the source of egg masses for the above transfers). The partially formed galls resembled *Pineus* spp. galls; the bases of the needles and the stems were partially swollen but were not fused laterally. Other less successful trials were made where some hatching had occurred before the egg masses were removed. Chambers typical of *A. cooleyi* were present at the base of the gall where a few nymphs had settled, and there were a few distorted needles toward the top where no nymphs had settled. These findings agree with those of Friend (9) and Plumb (13) who concluded that the feeding of the fundatrix in the spring initiated gall formation in *A. abietis* L. but that the feeding of the gallicolae was required for the complete formation of the gall.

The nymphs pass through four instars within the galls. They are a bright reddish-brown colour, and are covered with a fine powdery wax. The external cuticle is thin. Although no gland areas are visible on the first-instar nymphs, they may have a band of wax powder on the dorsal surface of the thorax and abdomen. The honeydew excreted by the nymphs is covered with a waxy pulverulence, so that the droplets do not coalesce. Occasionally the cast skins may be filled with honeydew. The third-instar nymphs have heavy ridges at the sides where the wing pads develop in the fourth instar. The eyes of the fourth-instar nymphs are black and the antennae, tips of the wing pads, and feet are light grey. They emerge from the galls, settle on the needles, and moult to the adult stage.

The adults are a dark red-brown colour with a heavily sclerotized thorax. The antennae, legs, and wings are light grey-green and the costa of the forewing is bright green; these colours change to light brown in older insects. They fly to Douglas fir where most of them settle on the lower surface of the current year's needles. Wax is secreted in two fan-like strands from the anterior margin of the head and in a flocculent mass from the abdomen. The wax from the abdomen, covered by the wings, protects the eggs. The adults are parthenogenetic. The average number of eggs laid was 65, in 10 counts.

### *Sistentes*

The sistentes are the overwintering generation on Douglas fir. They are the progeny of the gallicolae migrantes which migrate from spruce in late summer. The nymphs hatch about three weeks after the gallicolae have oviposited. The majority of these nymphs settle and overwinter on the lower surface of the needles of the current year's growth, facing the tips of the needles.

Some of the sistentes may originate as progeny of the second generation of wingless females (progredientes) which were on Douglas fir the previous summer. In 1955 the progeny of the progredientes died. It is not known whether this occurred in 1954, so that the sistentes studied in 1955 may have come from two sources.

Although the sistentes are reported to go through three nymphal instars, only two were distinguished in this investigation, but the number of specimens mounted was small, and one instar may have been missed. The newly hatched nymphs are light brown in colour with a darker prothorax and head. They gradually darken until they appear black, and secrete a fringe of white wax around the edge of the body. At this stage they are flattened, with the legs folded under the body. The first moult occurs in the spring. The second-instar nymphs are light brown and the body is covered with wax. The adults are similar in appearance, with wax in curled strands over the body. The sistentes are smaller than the fundatrices on spruce, and secrete less wax.

The adults are parthenogenetic females; the number of eggs laid varies widely. The average number of eggs laid by 18 females was 23, with a range from six to 52. The eggs are light yellow-green in colour when laid, but change to a light brown. The fecundity of parthenogenetic females in the different generations decreases the further removed they are from the sexual generation (Table I). Possibly the sistentes which laid small numbers of eggs were the progeny of progredientes rather than gallicolae.

TABLE I.  
Number of eggs laid by different generations of parthenogenetic females.

Generation	No. counts made	Average no. eggs	Range in nos.
Fundatrix.....	3	187*	90-352
Gallicola migrans.....	10	65	28-103
Sistentes.....	18	23	6-52
Sexupara.....	22	13	5-20
Progrediens.....	11	15	3-25

\*Observation suggests about 200 is the usual number.

The progeny of the sistentes are of two kinds; winged parthenogenetic females, the sexuparae, which migrate to spruce, and wingless parthenogenetic females, the progredientes, which remain on Douglas fir. The proportion of these two generations varies in different broods (Table II). The counts made in 1955 were at a locality where most of the observations for the present investigations were made. Those in 1957 were at a locality about three miles distant. Other observations, where no counts were made, also suggested that local populations varied. Collections made at Field, B.C., and Coleman, Alta., contained a higher proportion of progredientes.

### *Sexupara*

The sexuparae are the winged generation which migrates from Douglas fir to spruce. They are part of the progeny of the sistentes. Hatching begins

TABLE II.

The proportion of progredientes to sexuparae (progeny of the sistentes) in three counts.

Date	Number counted		
	Sexuparae	Progredientes	*Doubtful
6-VII-55. ....	63	5	16
15-VII-55. ....	72	4	0
3-VII-57. ....	84	76	11

\*Nymphs too small to distinguish form.

about a week after oviposition at the time when the buds are bursting. The nymphs move to the new growth, and develop in a short time to winged adults. Most of the nymphs prefer the upper surfaces of the needles.

There are four nymphal instars. The nymphs resemble those of the gallicolae except that the gland areas have fewer glands. Wing pads are present on the fourth-instar nymphs. The nymphs are light yellow-brown in colour when first moulted but become darker brown after a short time. Wax is not noticeable on the abdomen in any of the nymphal stages but it is present on the dorsal and ventral surfaces of the head. The feeding causes slightly depressed yellow patches on the needles which may turn green after the adults have left, but the needles often remain distorted.

Moulting to the adult stage was observed in one specimen. It took one hour and 15 minutes for the adult to emerge and expand its wings. Two hours later wax was present on all parts of the body; the longest strands were produced on the abdomen. The adults are heavily sclerotized except for the ventral surface of the abdomen. The eyes, head, and metathorax are dark grey-black in colour; the rest of the body is dark brown. The wings are grey with the costa grey-green and the bases of the wings bright green. The colour of the wings darkens and becomes light brown with age. Wax is produced in uncurled strands from the abdomen; this wax and the folded wings protect the eggs. The number of eggs deposited by these parthenogenetic females varied from five to 20 in 22 counts; the average number was 13. If a settled female is disturbed after oviposition begins she is unable to move the wings or legs but she can move the mouth parts. Some females removed their mouth parts from the needles when oviposition was completed.

#### *Progrediens*

The progredientes are the wingless summer generation on Douglas fir and constitute part of the progeny of the sistentes. The nymphs are usually on the new needles.

The present investigation suggests that in this area the progredientes are unimportant in the cycle of *A. cooleyi*. In 1955 they were not numerous and none of their progeny was alive by late summer. In 1956 there was almost 100 per cent mortality of the sistentes in the spring, so the generations on fir were not studied. In 1957 they were more numerous and some of their progeny may have survived. These were seen only as nymphs and resembled sistentes.

As far as is known, hatching of the nymphs and the seasonal development is similar to that of the sexuparae. Because of the small number of specimens the number of nymphal instars was not determined. The nymphs are light brown in colour and resemble the sistentes. After the first instar they can be

distinguished from the sexuparae by larger gland areas, which are dark grey and prominent. The adults produce wax in a flocculent mass resembling that of the sistentes.

The fecundity of these parthenogenetic females varied widely. The average number of eggs in 11 counts was 15, with a range of from three to 25. The progredientes present in 1955 produced smaller numbers of eggs than those in 1957. As mentioned above, the proportion of progredientes to sexuparae was higher in 1957.

### *Sexualis*

The sexuales are the progeny of the sexuparae and this is the only generation where sexual reproduction occurs. The sexuales were not described by early workers in North America. Gillette (10) recorded that the eggs of the sexuparae hatched in about a week and the nymphs remained without developing until the next spring. Chrystal (6) made the same observation for this species in British Columbia, and stated that the nymphs were those of stem mothers (fundatrices). Later, in Britain, Chrystal (7) found the sexual generation and recorded that there were five instars, although he did not study them in detail. Annand (1) found only males in California. Cameron (5) also saw the sexual generation and reported four moults. Franke-Grossman (8) saw the sexual generation of *A. cooleyi* in Germany.

Information concerning this generation is often scarce in work with other species. Balch and Underwood (2) saw four moults in *Pineus pinifoliae* (Fitch) in New Brunswick. The nymphs stayed under the parent female as long as possible and then settled in a row along the same needle. Varty (14) described four nymphal instars for *A. nüsslini* C.B. in Britain. In this species the newly hatched nymphs crawled at random over the crown of the tree for a few hours or days and then settled on the leaf tips of the new shoots. The moults were easily counted behind the nymphs.

During the present investigation considerable difficulty was experienced in finding this generation and in following its development. Results were finally obtained by rearing material indoors. Twigs artificially infested with sexuparae by caging in the field were brought indoors and placed in vials of water set sideways to simulate natural conditions. Wax held the twigs and vaseline sealed them in, and caught any wandering sexuales. Sheets of white paper were placed under the twigs to catch those that dropped and syrup was placed around the edges to catch wanderers. The observations made were then confirmed by field observations.

Hatching begins a week or more after oviposition by the sexuparae. During the first instar the nymphs remain under the parent female where they usually arrange themselves in a single row, each nymph facing the edge of the needle. They may remain here until the last instar or move away and settle near the female. Some last-instar nymphs wander farther; some were at the nodes and some on the paper, in the inside rearing. Only three nymphal instars could be distinguished, and no more than two moulted skins were ever found with a nymph. Measurements of the whip of the antenna of 49 nymphs were made in order to help determine the number of instars. These measurements, together with the fact that some first-instar nymphs were known because they had just hatched, and some last-instar nymphs were known because the adult antennae and glands in the females could be seen through the cuticle, suggested that there were only three instars. It is possible that the first two instars are so similar that they were not distinguished, since other workers have recorded four nymphal instars for this

and other species. The nymphs are a light reddish-brown colour. The last-instar nymphs take on a more reddish colour, more apparent in the males than in the females.

The adults move to the nodes of the twigs, travelling long distances from the parent female. Commonly the sexuparae settle on recent growth; often the sexuales are found at the nodes of old growth, as far as five years back. This tendency to move toward the centre of the tree would help to assure the finding of a mate, particularly in light infestations. One pair was observed mating at a node of a twig collected in the field. The copulating pair moved from the node but remained in contact after being disturbed, the male resting on the dorsal surface of the female. Oviposition occurs at the nodes, between the old bud scales and the twigs. The female usually faces the scales and rests upon them. She secretes a small amount of blue-white wax in fine strands before oviposition and this wax later surrounds but does not completely cover the egg. Little evidence was found to suggest that the female deposited more than one egg. Several females oviposited in vials or on filter paper. The female is so small in comparison to the egg that she appears to move away from the egg in oviposition. The abdomen remains telescoped after oviposition and the female soon dies. Dead females are often found near the eggs and dead males are sometimes found at the nodes, although adults often fell to the paper when reared indoors.

It is difficult to give an accurate sex ratio. A summary of the data obtained in five of the indoor rearing experiments is given in Table III. Although the sexes of all the individuals produced by the sexuparae were not determined, the results suggest a sex ratio approaching 1:1.

TABLE III.

Progeny of sexuparae reared on five twigs indoors.

No. of sexuparae per twig	Eggs unhatched	Males	Females	Nymphs, adults sex undet.	Total
1	0	1	9	5	15
2	5	0	11	0	16
3	0	12	0	5	17
5	0	12	9	2	23
20	0	27	31	53	111
Total 31	5	52	60	65	182

### Seasonal Development

A diagram representing a generalized life history of *A. cooleyi* as it occurred during the summer of 1955 at Kananaskis is given in Fig. 2. No attempt has been made to represent the percentage of the population in any stage at a given time, and each stage has been cut off at the place where most of the population had passed on to the next stage. In the field there was overlapping.

The fundatrices pass through the second and third instars in a period of about two weeks in the spring. Oviposition is completed in about two weeks and hatching occurs in a relatively short time. The adult fundatrices often die before hatching is completed.

The beginning of gall formation is closely related to the time of the removal of the bud scales from spruce. In the three years of the investigation



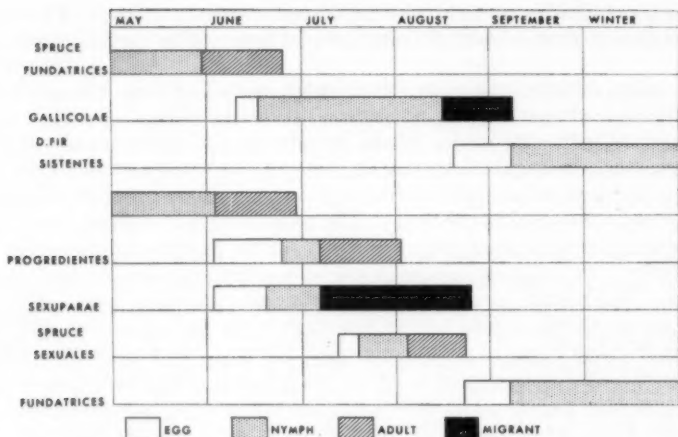


Fig. 2. A diagram of a generalized life history of *A. cooleyi* at the Kananaskis Experiment Station in 1955.

hatching of the gallicolae nymphs began just after the bud caps fell. The spruce developed approximately a week earlier in 1956 and 1957 than in 1955. Phenological observations made on the date of the bursting of spruce buds between 1952 and 1957 showed this varied as much as 23 days. The gallicolae develop within the galls over a long period of almost two months. In a small area, opening of all the galls occurs within a few days. The winged adults begin oviposition soon after they settle on Douglas fir and hatching of the sistentes occurs in two to three weeks.

The sistentes on Douglas fir begin development in the spring at about the same time as the fundatrices on spruce. There is wide variation in the time required for development in the sistentes; this may be a result of different origins, as mentioned above. Oviposition begins soon after the adult stage is reached and the incubation period is two to three weeks. Most sistentes are dead by the time their eggs have hatched.

The two generations which are the progeny of the sistentes develop to the adult stage in about a month. This results in the production of the winged generation on Douglas fir a month or more before the winged gallicolae on spruce mature.

The progredientes begin oviposition immediately. In 1955 most of the females laid small numbers of eggs, and by the middle of August the eggs had hatched and no trace of nymphs was found.

The sexuparae settle on spruce and begin oviposition in a few days. The adults remain alive much longer than the progredientes; some females remain alive after their eggs have hatched.

The sexuales hatch in one to two weeks. They develop to the adult stage in approximately two weeks and in another two weeks all the adults have oviposited and are dead. Indoor rearing showed that individual adults live a much shorter time than this; one female lived two days, and two females lived three days from the time of the last moult to oviposition and death.

The seasonal development in other areas varies from that described here. The following examples give some idea of how wide this variation is. Gillette (10) recorded the hatching of gallicolae nymphs on May 20 and opening of

the galls in early July in 1906 at Fort Collins, Colo. In Vancouver, B.C., Chrystal (6) recorded the earliest gall opening was June 25, 1915. In California Annand (1) recorded sexuparae on May 20 (compared to early July at Kananaskis). Peterson (12) in Indian Head, Sask., recorded that some galls opened on July 12 in 1943, and this continued until August 18. Forest Insect Survey records for Alberta and Saskatchewan between 1946 and 1950 showed that galls opened as early as July 26 and as late as September 5. In Britain Chrystal (7) found sistentes beginning development in mid-March in 1920; sexuparae appeared by early June. When the complete life cycle was recorded in Britain by Cameron (4) the galls opened in late August and September.

#### Caging of *Gallicolae* on Spruce

*Gallicolae* migrantes have been caged on spruce twigs to see if a few of their progeny would survive on that host. There are many reports in the Forest Insect Survey of what is apparently *A. cooleyi* from areas where there is no Douglas fir. No conclusive results were obtained but some *gallicolae* settled and oviposited and the nymphs which hatched remained alive in September or October. Some of these nymphs were alive the following May but were dead by June. Table IV gives the results of caging begun in 1956 and followed through into 1957. One gall was used in each cage. The checks consisted of half of a gall used on spruce in the other part of the experiment. They were only followed long enough to see that the *gallicolae* settled and oviposited on Douglas fir.

TABLE IV.  
Results of caging *gallicolae* on spruce in 1956 and their survival in 1957.

Host	Number of Cages							
	Summer		Fall			May		June
	None settled	Settled	With no nymphs	With dead nymphs	With live nymphs	With dead nymphs	With live nymphs	With dead nymphs
Douglas fir.....	4	15						
Spruce.....	10	28	5	1	22	6	16	16

#### Natural Control

The sistentes suffered the highest mortality of any generation in the spring of 1956. At the location where most of the observations were made in 1955 there was almost 100 per cent mortality of overwintering nymphs. Only a few live nymphs were found close to the ground, and it is likely that these survived because they were covered with snow. High mortality occurred as far west as Banff, but at Field, B.C., the nymphs survived the winter. This mortality resulted in scarcity of galls in 1957, and it is believed that a similar mortality caused the scarcity of galls at Waterton. There was no evidence of similar mortality of overwintering fundatrix nymphs on the underside of the spruce twigs in the spring of 1956.

Loss of nymphs through wandering and dropping from the needles was evident in some generations. Counts were made of the number of eggs of the

fundatrices after hatching was completed and of nymphs in the galls. One female had laid 352 eggs; 11 failed to hatch, 182 settled in the gall and 159 were lost. Many adult sexuales dropped to the paper during the indoor rearing. Field examinations substantiated the idea that many were lost because the number of sexuales was always smaller than would have been expected from the number of sexuparae present. Some of the sexuales may survive on branches below. One small caged tree which was infested with six sexuparae had only three galls the following year, so that there was a high mortality of sexuales or fundatrices, or both.

Predation was not an important mortality factor. Two species of Syrphidae were found, but none was reared to the adult stage. The eggs of syrphids were found in a few egg clusters of each stage of the parthenogenetic generations, and in one gall cavity. Sexuales nymphs still under the parent sexuparae and adult progredientes and their progeny were attacked. Small unidentified mites were believed to have attacked sexuales and their eggs at the nodes. One specimen of a coccinellid, *Mulsantina* sp., was the only other predator recorded.

### Morphology

Gillette (10), Annand (1), and Chrystal (7) have described most of the stages of *A. cooleyi*, with varying detail. Descriptions presented here are not complete, but a few differences are pointed out, and some details added. The most outstanding variation between generations occurs in the gland facets, their sizes, shapes, and the arrangement of the plates upon which they occur. The dorsal plates are either heavily sclerotized and distinct, or not clearly outlined. The gland facets vary in size and are either round or angular in outline. Small pores with regular round edges are also present on some plates. The ventral plates are only slightly sclerotized, and always have small round gland facets. The dorsal plates are in three pairs, arranged in a single transverse row on each segment from the mesothoracic to the sixth or seventh abdominal segment. There may be indistinct areas on the eighth and ninth abdominal segments. On the head and prothorax there are two rows. Fusion of plates occurs laterally or longitudinally. The central pair of gland areas on the dorsal surface is referred to as 'mesial', the one beside them as 'pleural', and the lateral one as 'marginal'.

### Fundatrix

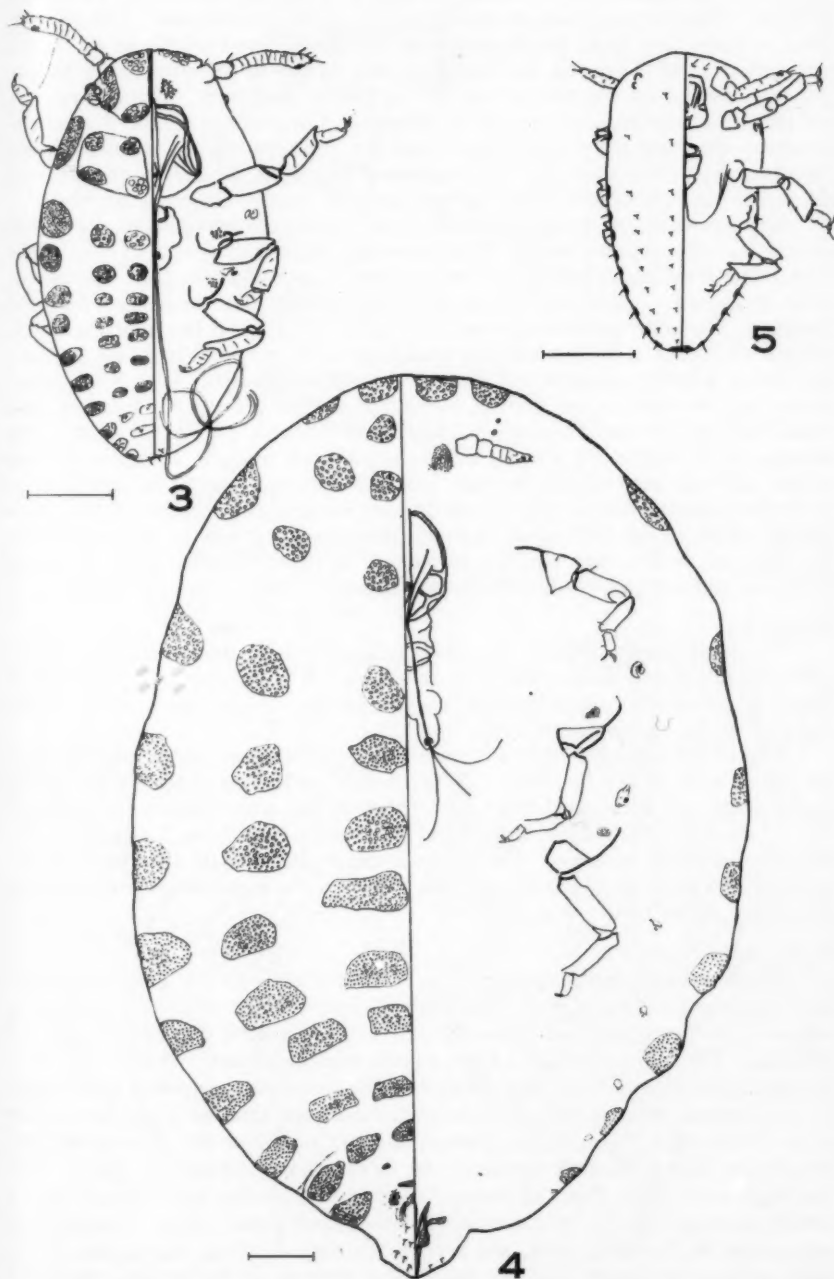
The first-instar nymph (Fig. 3) is distinguished by its angular gland facets and the presence of large sclerotized areas, which are fused plates, on the head and prothorax. All the dorsal gland facets have this angular form and all are heavily outlined (Fig. 14a), except those on abdominal segments six and seven, which are only faintly outlined or are represented by setae.

The adult has distinct plates with clearly outlined gland facets (Fig. 4). The plates toward the anterior end have many angular glands merging into rounded ones at the edges. The posterior plates have a higher proportion of round gland facets (Fig. 14d). The angular gland facets are not as large or as sharply outlined as those of sistentes and progredientes (Fig. 14c, 14g). Annand's material had reticulations rather than round gland facets at the edges of the plates.

The ventral gland areas of the head and coxa (Fig. 14e, 14b.) are similar on all stages where present but they vary in size. Annand described a ventral gland area mesad to the prothoracic coxa, but it was lacking or only represented by four or five setae in the specimens examined.

### *Gallicola Migrans*

The first-instar gallicola (Fig. 5) has no distinctive features except that prominent setae replace the gland areas on the thoracic and abdominal segments.



Figs. 3-5. *Adelges cooleyi*. 3, fundatrix nymph, first instar; 4, fundatrix adult; 5, gallicola nymph, first instar.

Gland facets are present on the marginal areas of a few specimens, but are faintly outlined. These nymphs are the smallest of any of the generations. The second-instar nymphs have small gland areas with few gland facets on the head, on the marginal areas of the thorax and abdomen, and on the mesial areas of the thorax and occasionally on the first or second abdominal segments. Gland facets on the pleural area occur only on the prothorax. The number of gland areas increases in the third and fourth instars until the arrangement in the fourth instar resembles that of the adult, but there are rarely glands on the mesial areas beyond the fourth segment of the abdomen, and the areas on the abdomen are small.

Approximately 50 gallicolae adults were examined carefully to check the variation in arrangement of the gland areas and other characters. These adults were taken from single gall collections, so that six to ten adults from one parent were compared. There was as much variation within a family as between families. The adult gallicola is shown in Fig. 6. The gland facets of the dorsal surface are round in outline and the arrangement of the gland areas on the head and thorax is fairly constant, but that on the abdomen varies. The head, mesothorax, and metathorax are heavily sclerotized so that there is no separate plate around each gland area (Fig. 14f). There are two heavily pigmented areas on the mesothorax as well as the gland area on the posterior margin. The mesial areas of the abdomen tend to broaden and fuse at the centre line. The pleural areas are broken up into small groups of gland facets, some without plates. Gland areas usually occur as far back as the seventh abdominal segment in the mesial area but they are small. The number of hamuli on the hind wing (Fig. 9) varies from two to five; individuals often have a different number on each side.

#### *Sexupara*

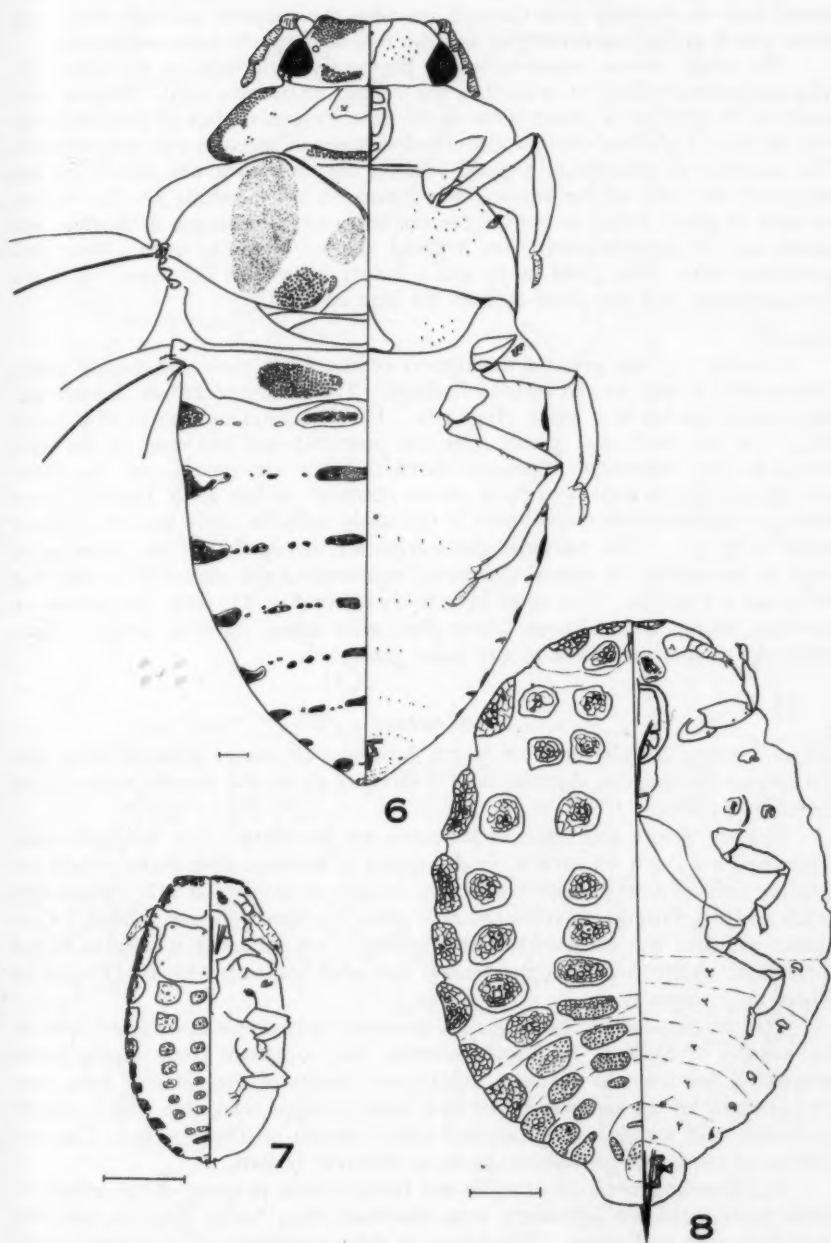
The setal arrangement of the first-instar nymph is similar to that of the gallicola, but small plates surround each seta. A suggestion of gland facets occurs at the anterior margin of the head and on the marginal areas of the fourth and fifth abdominal segments.

The adults show considerable variation in the number and arrangement of the gland areas of the abdomen. There is less tendency toward fusion of the mesial areas, and there are fewer gland facets in the areas than in the gallicola, but a few individuals have large areas with many glands as far back as the seventh abdominal segment. The antennae are usually shorter than those of the gallicola, but they also vary in size. In 18 adults the number of hamuli on the hind wing varied from one to four.

#### *Sistens and Progrediens*

The first-instar sistens nymph (Fig. 7) is distinguished by the arrangement and appearance of the plates. The head is covered with two sclerotized areas separated at the centre line. Gland facets occur on these areas anteriorly and laterally. The prothorax has a large square sclerotized area on each side over the mesial and pleural areas, each formed by the fusion of four plates, with a pore at each corner. A long narrow plate on the marginal area has gland facets only at the outer edge. The mesial, pleural, and marginal areas on the mesothorax, metathorax, and abdominal segments one to four have rectangular plates. The marginals have gland facets at the outer edges; the mesials and pleurals have a central pore surrounded by reticulations rather than gland facets. Gland facets are present on the fifth, sixth, and seventh abdominal plates; the mesials of the sixth segment are joined, and the mesials and pleurals of the seventh are joined laterally. Where gland facets do occur they resemble those of the fundatrix nymph. (Fig. 14a).





Figs. 6-8. *Adelges cooleyi*. 6, gallicola adult; 7, sistens nymph, first instar; 8, progrediens adult.

The progrediens nymph was not distinguished with certainty, but nymphs found later in the year than sistentes resemble the sistentes although they have more glands at the lateral margins and the reticulations are more outstanding.

The adult sistens resembles those previously described in the literature. The progrediens (Fig. 8) is similar, but certain characters vary. Counts were made of the number of gland facets on the anterior mesial plate of the prothorax, and the pleural plate of the first abdominal segment of sistentes and progredientes. The presence or absence of a gland area on the hind coxa was noted, and the length of the whip of the antenna was measured. The sistens has the smallest number of gland facets in both areas, the whip of the antenna is shortest, and about half of the specimens have a gland area on the hind coxa. Most progredientes have more gland facets and a longer whip than the sistens; all but a few specimens lack the gland area on the hind coxa.

### *Sexualis*

Chrystal (7) has given a description of the adult male and female which corresponds closely to the present findings. The male and female are not distinguishable in the first instar (Fig. 10). The last-instar nymph of the female (Fig. 11) has small wax glands near the posterior end and that of the male resembles the first-instar. Chrystal stated that the arrangement of the mesial and pleural gland areas was "still rather obscure" in the adult female. They were not seen on cleared specimens in this study and it is likely that they do not occur (Fig. 12). The marginal gland areas are arranged as if on plates as far back as the seventh or eighth abdominal segment but the cuticle is so thin that no plates are visible. The adult male is shown in Fig. 13; setae are present on the head, thorax, and abdomen where gland areas appear on other forms. These adults are smaller than those of any other generation.

### Summary

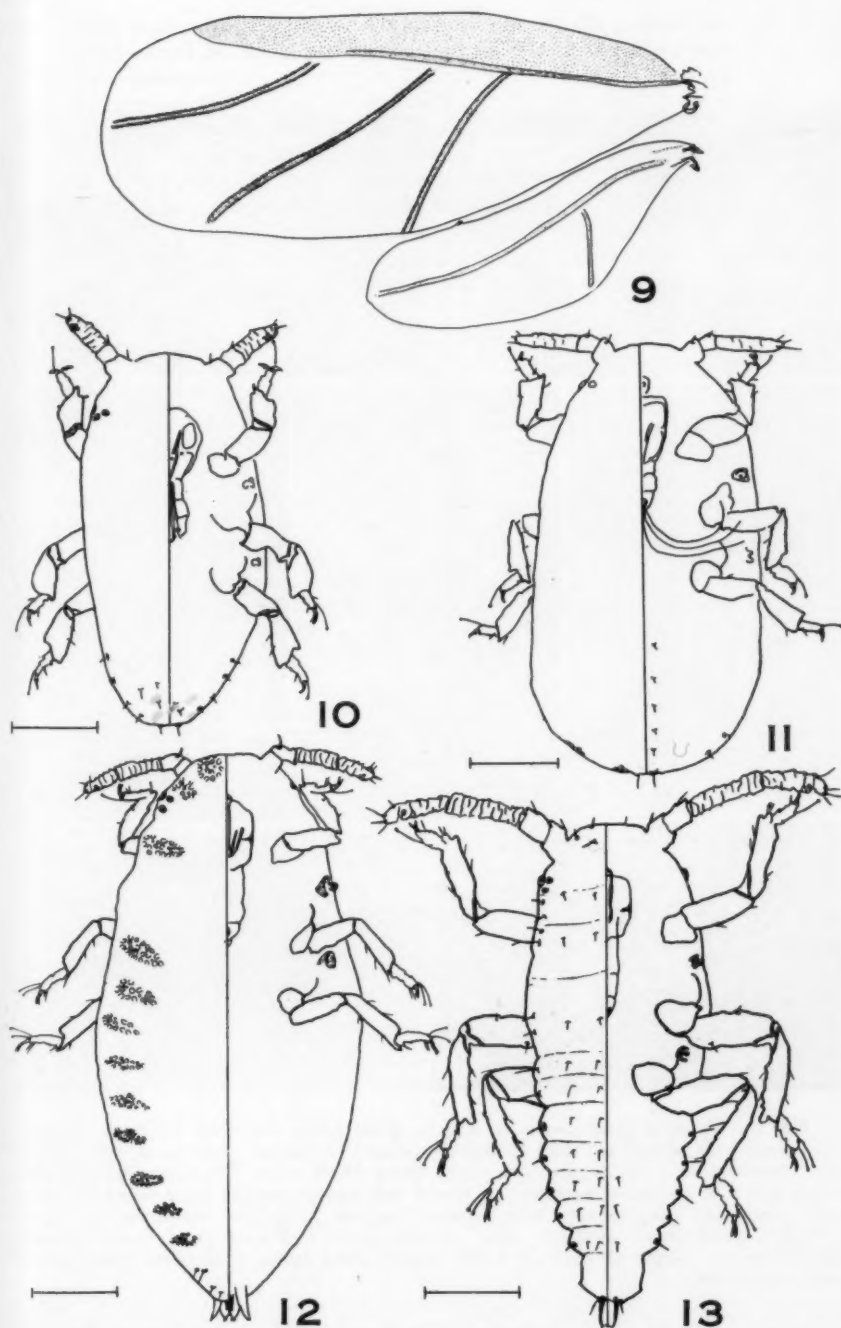
*A. cooleyi* is indigenous to North America. It causes galls on white and Engelmann spruce; the alternate host is Douglas fir on the eastern slopes of the Canadian Rockies.

The life history and habits of six forms are described. The fundatrix overwinters as a nymph on spruce; in the spring it matures after three moults (or possibly only two) and deposits as few as 90 eggs or as many as 352. These eggs hatch and the nymphs move to the new growth where galls are formed. Conclusive evidence was obtained that the feeding of the fundatrix is essential to gall formation. After four nymphal instars the adult gallicolae fly to Douglas fir where they oviposit.

The progeny of the gallicolae are sistentes; they overwinter as nymphs on the needles of Douglas fir. Some sistentes may originate from a progrediens generation but this was not seen. Only two moults of the sistentes were seen. The progeny of the sistentes are of two kinds: winged sexuparae which migrate to spruce, and wingless progredientes which remain on Douglas fir. The proportion of these two generations varies in different broods.

The sexualis generation of males and females is the progeny of the sexuparae. Their habits have not previously been described from North America, but they have been seen in Europe. The habits of this generation are described. Only three nymphal instars were distinguished.

Gallicolae were caged on spruce. Adults settled and oviposited; some nymphs survived the winter and were alive in May but died in June.



Figs. 9-13. *Adelges cooleyi*. 9, gallicola wings, 10, sexualis nymph, first instar; 11, sexualis nymph, last instar female; 12, sexualis adult, female; 13, sexualis adult, male.

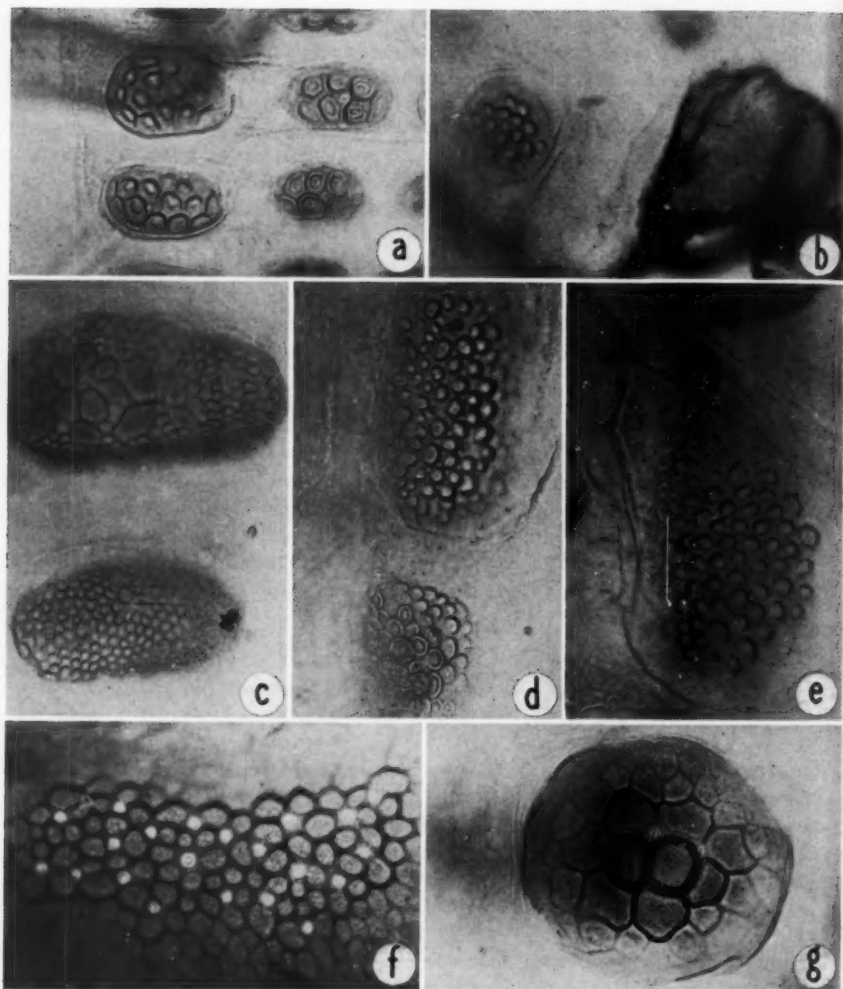


Fig. 14. Types of gland facets. a, Angular gland facets, first-instar fundatrix, marginal and pleural areas, second and third abdominal segments. b, Round gland facets, adult fundatrix, mesocoxal area. c, Angular and round gland facets, adult progrediens, pleural area, fourth and fifth abdominal segments. d, Round and slightly angular gland facets, fundatrix adult, pleural and marginal area, sixth abdominal segment. (Anterior margin on the right). e, Round gland facets, fundatrix adult, antennal area. f, Round gland facets, gallicola adult, posterior margin of head. g, Large angular gland facets, progrediens adult, pleural area, mesothorax.

The seasonal development is described for all the generations and a table of a generalized life history as it occurred in 1955 at the Kananaskis Experiment Station is given.

Natural control factors are discussed. Death occurred in the sistens generation apparently because of adverse weather conditions. Wandering of nymphs caused losses in some generations. Predation was not an important mortality factor; two unidentified species of Syrphidae were present, mites were believed to attack the sexualis generation, and one specimen of *Mulsantina* sp. was found.

The morphology of all the generations has been described previously. Short discussions of each stage are given with drawings to illustrate the variation between generations.

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**The Larva of *Profenusa alumna* (MacG.)  
(Hymenoptera: Tenthredinidae)<sup>1</sup>**

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Among the numerous insects attacking the leaves of birch in North America are *Profenusa alumna* (MacG.) and *Fenusa pusilla* (Lep.), both of which are leaf-miners belonging to the tribe Fenusini. Various attempts have been made to separate the known fenusine larvae, all of which are very similar (Yuasa, 1922; Ripper, 1931; Lorenz and Kraus, 1957; Lindquist, 1959), but the larval morphology of *F. pusilla* only has been described in detail (Friend, 1933; Daviault, 1937). In this paper the larval morphology of *P. alumna* is described from material collected some 60 miles north of Sault Ste. Marie, Ontario, in 1955.

**First Instar**

The first-instar larva (Fig. 1,A) is approximately 1.3 mm. long, depressed, and tapers posteriorly from the prothorax. The comparatively large, triangular head is heavily sclerotized, and light brown. The prothorax is wider than the head and bears ventrally a large rectangular brown patch with a smaller anterolateral patch on each side. The abdomen is white.

The head capsule is twice as wide as long, having an average width of 0.134 mm. Epicranial arms are very indistinct and do not attain the anterior margins of the head. The vertex projects slightly posteriorly and is covered by the anterior margin of the pronotum. Posterior to the antennae are three short setae (Fig. 3,A) associated with several small pores. The tentorium, very conspicuous in cleared specimens, is narrow with slender dorsal arms attached to the head capsule slightly laterad of the epicranial arms. The labrum (Fig. 2,A) is deeply bilobed, and apparently longer than in the later instars, with an average width of 0.071 mm. and an average length of 0.037 mm. The epipharynx bears two curved rows of coarse, roughly truncate setae, and the surface is covered with large round plates diminishing in size medially and posteriorly. The mandibles (Fig. 2,D) are large and triangular with one to two setae at the outer basal angles; the incisor area bears a deep groove with three teeth on each side, the last tooth on the ventral side being expanded into a large, thin blade; on the right mandible there is a short, sharp, conical tooth set inside the groove. The maxillae (Fig. 2,G) bear four-segmented palpi which have two setae on the third segment; a long, conical, apically blunt galea; and a rounded lacinia bearing five coarse, sub-equal setae. The labium (Fig. 2,G) is broad, with two very short palpi. The hypopharynx is expanded and fleshy, with curved rows of coarse setae changing to finer plates in the gorge.

The prothorax is without annulations and the meso- and metathorax each have two obscure annulations across the dorsum. The prothorax has a large spiracle without any surrounding sclerotic plate whereas the mesothorax has a minute spiracle near the posterior margin. The thoracic legs (Fig. 3,D) are short, subconical knobs with three light-coloured basal setae. The ventral epidermis bears long transverse ridges that are better developed in the central part of each segment; the intersegmental areas and the dorsal areas bear shorter rounded plates that are widely spaced.

The abdominal segments 1 to 7 are distinct and separate with well-defined pleural lobes. Each segment bears three vague annulations. There are no prolegs or pedal lobes. Segments 8 to 10 form a large anal mass, obscurely seg-

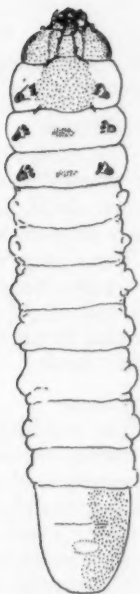
<sup>1</sup>Contribution No. 508, Division of Forest Biology, Research Branch, Department of Agriculture, Ottawa, Canada.



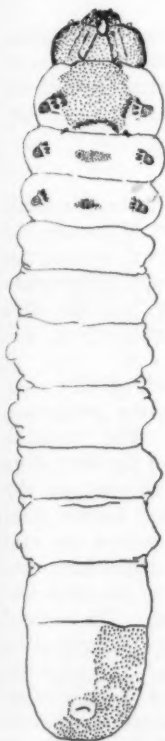
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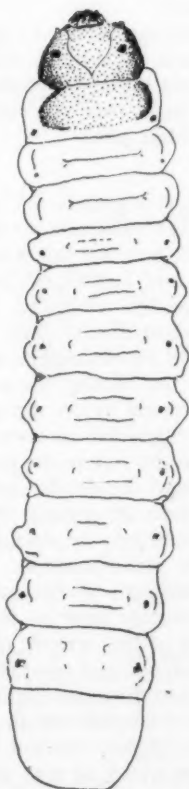
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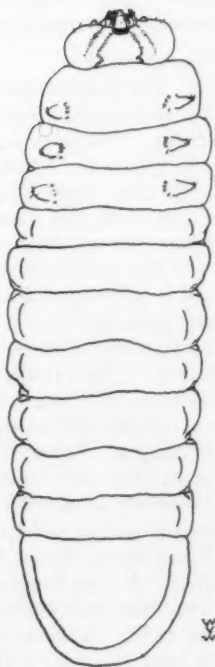
C



D



E



F

Fig. 1. *Profenusa alumna*, larva. A, First Instar, ventral. B, Second Instar, ventral. C, Fourth Instar, ventral. D, Fifth Instar, ventral. E, Fifth Instar, dorsal. F, Sixth Instar, ventral.

mented and without annulations. The anal slit is transverse and simple. The integument bears small, widely spaced plates.

#### *Second Instar*

The second-instar larva (Fig. 1,B) is approximately 1.6 mm. long but otherwise essentially similar to the first instar. The prothorax has a pale amber pronotal shield and a large pale-amber area ventrally. The thoracic legs are slightly sclerotized and pale amber. The abdomen is dull white.

The average width of the head capsule is 0.42 mm., of the labrum 0.078 mm.; the average length of the labrum is 0.051 mm. The mandibles have irregular teeth, that of the groove often being bidentate. The hypopharynx bears coarser setae than in the first instar. The integument has finer transverse ridges than in the first instar.

#### *Third Instar*

The third-instar larva is approximately 2.1 mm. long. The prothorax and mesothorax are like that of the second instar but the metathorax also has a small, transversely-oval marking ventrally. The legs are prominent and lightly sclerotized. Although the abdomen still tapers slightly, it is more cylindrical than in the earlier instars with the anal segments being almost as wide as the first segments. The abdomen is dull white.

The average width of the head capsule is 0.56 mm., of the labrum is 0.11 mm.; the average length of the labrum is 0.075 mm. Although structurally similar to the second instar, the spiracles have slightly pigmented sclerotic areas around the ostia. The integument of the anal mass ventrally has concentric plates surrounding a smooth, unmarked central area.

#### *Fourth Instar*

The fourth-instar larva is approximately 4.5 mm. long. The head capsule is amber brown, bearing two darker spots, one on each side laterad of the coronal suture. The prothorax has a dark pronotal shield and a large, brown, rectangular area ventrally. Both the meso- and metathorax have single, small, transversely oval areas slightly behind the middle ventrally. The thoracic legs are dark amber with the basal spines almost black. The abdomen is cylindrical, dull white; the spiracles are surrounded by prominent amber areas.

The head capsule, widest at the middle, has an average width of 0.73 mm., and is prolonged dorsally and covered by the anterior margin of the pronotum; the posterior dorsal margin is expanded into two thin flaps. The posterior ventral margin is thickened, especially where the posterior arms of the tentorium join it. The maxillary cardines and the slender intersegmental<sup>2</sup> sclerites are also anchored at these points. No ocelli are present although the dark brown spots on the dorsum of the head capsule may represent the position where the eyes would be. Setae (Fig. 3,B) are not numerous. There is a single long seta behind the antero-lateral angle and two shorter setae posterior to the antennae. These are apparently the only constant setae on the head capsule. The coronal suture, almost one-half the length of the capsule, divides into the epicranial arms which curve outwards and become obsolete towards the antennae. The antennae (Fig. 3,B) are single-segmented structures bearing numerous small sensory areas. The front is bounded by a narrow clypeal area that is somewhat produced from the head. Anterior to this is the slightly bilobed labrum (Fig. 2,B), two-thirds as long as wide, with an average width of 0.13 mm. and an average length of 0.098 mm. The epipharynx bears two arcuate rows of coarse, blunt setae, usually

<sup>2</sup>The term "intersegmental" is preferred to "cervical" because similar sclerites exist between the meso- and metathorax and between the metathorax and the first abdominal segment.

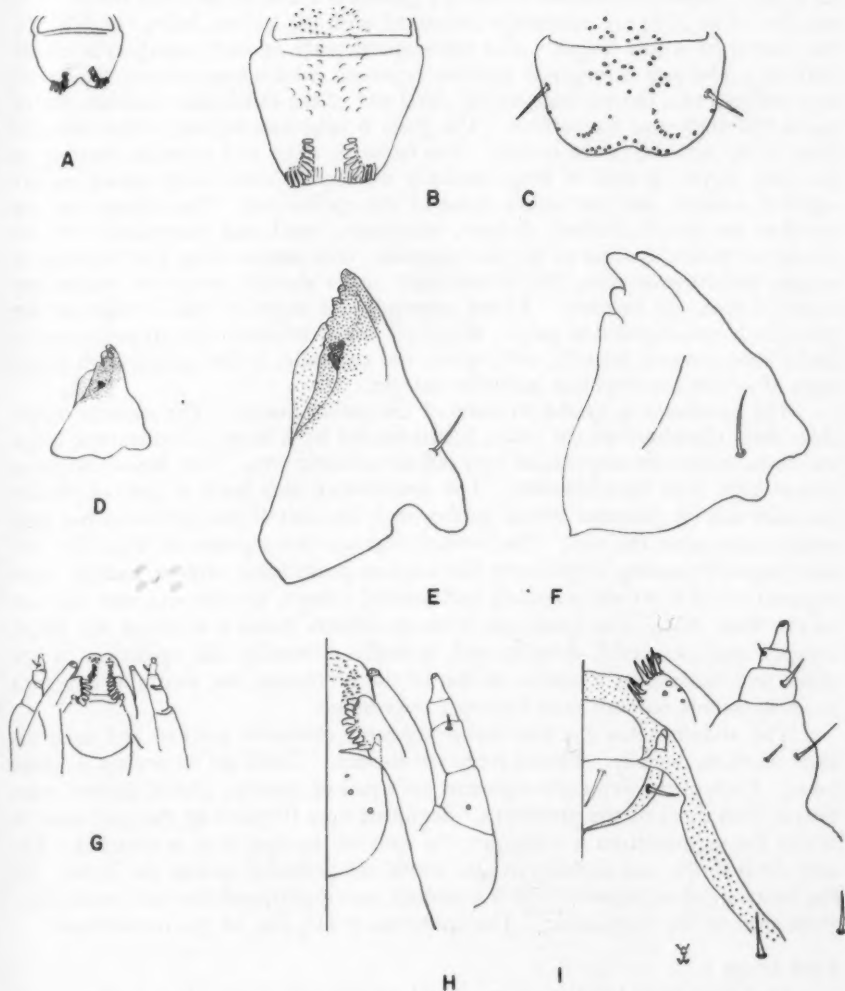


Fig. 2. *Profenusa alumna*, larva. A, Labrum and epipharynx, first instar. B, Labrum and epipharynx, fourth instar. C, Labrum and epipharynx, sixth instar. D, Mandible, right, first instar. E, Mandible, right, fourth instar. F, Mandible, right, sixth instar. G, Maxilla and labium, left side, first instar. H, Maxilla and labium, left side, fourth instar. I, Maxilla and labium, left side, sixth instar.

eight in number, on either side of the mid-line; antero-medially of these are rows of bristle-like plates leading to a smooth central area. The mandibles (Fig. 2,E) are similar; each is triangular and elongate, and there is a single long seta near the outer basal angle. Along the incisor area is a moderately deep groove, one edge of which is slightly crenulate; within the groove is a low, mound-like tooth. The maxillae (Fig. 2,H) are intimately connected with the labium, being fused with it for almost its whole length. The three apical parts of each maxilla are clearly defined. The palp is long and has four segments, with a long seta on the second segment and two shorter ones on the distal end of the third; there are also several pores scattered over the surface. The galea is long and digitate with a rounded apex, lying external to the lacinia. The lacinia is short and rounded, bearing on its distal surface a row of long, medially directed, coarse, blunt spines, usually eight in number, and not unlike those of the epipharynx. The stipites and the cardines are poorly defined, elongate structures, fused, and connected with the thickened ventral margin of the head capsule. The labium (Fig. 2,H) consists of a long membranous area, the sub-mentum, and a shorter, narrower, posteriorly rounded area, the mentum. At the antero-lateral angles of this sclerite are the two short, two-segmented palpi. Attached to the labium is the hypopharynx, a fleshy lobe covered laterally with spines and centrally, in the gorge, with plates, each of which has a spinous posterior margin.

The prothorax is similar to those of the earlier instars. The spiracle, larger than those elsewhere on the body, is surrounded by a series of concentric rings, and these in turn are surrounded by a diffuse sclerotic area. The meso- and metathorax each bear two annulets. The mesothorax also bears a pair of minute spiracles near its posterior lateral border, each like that of the prothorax but only about one-quarter the size. The thoracic legs are two-segmented (Fig. 3,E), the basal segment bearing three heavy black spines on its inner surface, and the distal segment being short and rounded, and bearing a short, slender seta near the base on the inner side. The epidermis of the prothorax shows a series of flat plates, roughly quadrate, both dorsally and ventrally. Dorsally the epidermis of the meso- and metathorax is similar to that of the prothorax, but ventrally it bears a series of minute mounds each bearing a microspine.

The abdomen has the first seven segments distinctly marked and each has three annulets dorsally. Pleural lobes are distinct. There are no prolegs or pedal lobes. Each of the first eight segments has a pair of spiracles placed slightly more dorsad than those of the prothorax. Segments 8 to 10 make up the anal mass, in which the segmentation is indistinct; the apex of the anal mass is rounded. The anal slit is simple and slightly arcuate across the posterior end of the body. On the ventrum of segment 9 there is a smooth area slightly smaller and more transverse than in the third instar. The epidermis is like that of the metathorax.

#### *Fifth Instar*

The fifth-instar larva is approximately seven mm. long. It is similar to the fourth-instar larva but the sclerotized areas are darker brown. The abdomen is fully cylindrical.

The average width of the head capsule is 0.88 mm., and of the labrum 0.156 mm.; the average length of the labrum is 0.116 mm. The ventral smooth patch on segment 9 is small and circular.

#### *Sixth Instar*

The sixth-instar larva is about six mm. long, slightly shorter than the fifth. It is quite cylindrical with a typical sawfly head and hypognathous mouth parts.



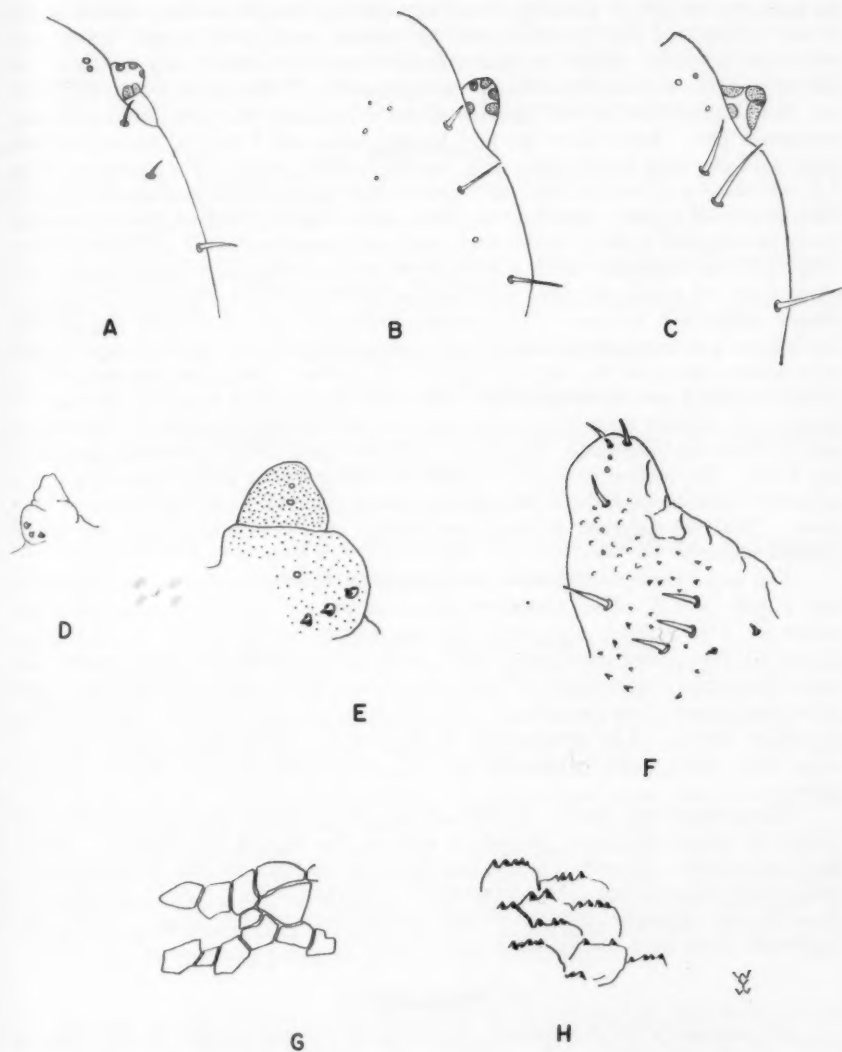


Fig. 3. *Profenusa alumna*, larva. A, Antenna and head setae, first instar. B, Antenna and head setae, fourth instar. C, Antenna and head setae, sixth instar. D, Prothoracic leg, first instar. E, Prothoracic leg, fourth instar. F, Prothoracic leg, sixth instar. G, Dorsal integument, sixth instar. H, Ventral integument, sixth instar.

The head capsule is pale amber with two darker spots. The pronotal shield and the legs are pale amber; the basal spines on the legs are only slightly darker. Otherwise the larva is unmarked.

The head capsule is widest at the middle with an average width of 0.88 mm.; its posterior margin is prolonged and covered by the pronotum. The coronal suture is long and the epicranial arms are almost equal to its length but do not attain the antennae. Setae are numerous but most of them are not constant. A cluster of setae is found posteriorly on the vertex. Three long setae (Fig. 3,C) are found posterior to and laterad of each antenna, and are associated with numerous pits. Also, there are two frontal setae and a pair of frontal median pits, and two long labral setae with several median pores. The antennae (Fig. 3,C) are short and conical with one segment that bears several small sensory areas. The labrum (Fig. 2,C) is wider than long, and is slightly bilobed; the epipharynx bears two curved rows of very short setae and numerous pores. The mandibles (Fig. 2,F) are triangular with a long single seta near the outer basal angle; four sharp teeth, of which the third is the largest, form the incisor area, and there is a simple reticular groove. The maxillae (Fig. 2,I) are fused with the labium. Each bears a three-segmented palp with a single long seta on the first segment and two shorter setae on the large palpiger. The galea is long and digitate, with a simple rounded apex bearing sensory hairs and cones. The lacinia is shorter and bears a row of four long, sharp setae and two shorter separate setae. The stipites and cardines are ill-defined, elongate structures, fused to the posterior margin of the head. The labium (Fig. 2,I) consists of a long membranous submentum, and a shorter, transverse mentum bearing the two-segmented palpi and a pair of long setae. The hypopharynx is large and fleshy, with concentric rings of minute spinous clusters.

The three thoracic segments are essentially alike except that the prothorax has a pale shield. The venter is pale except for the short intersegmental sclerites. The thoracic legs (Fig. 3,F) are simple, conical lobes, each bearing a cluster of four spines at the apex, and a pore; basally there are three coarse, pale spines corresponding to those found in the earlier instars, and a fourth, finer spine somewhat posterior to the others. The spiracles lack the sclerotic rings found in the other instars. The integument of the dorsal surface has a mosaic pattern (Fig. 3,G), whereas the ventral surface (Fig. 3,H) has a series of minute elevated spines.

The abdomen is similar to that of the other instars, except that the setal pattern is apparently more regular, at least on the first seven segments. There are three annulets on each segment but these are obscured by the development of various secondary lobes. The integument is marked with a mosaic pattern both dorsally and ventrally, but the ventral plates have spinous edges. The intersegmental areas have smaller plates.

### Discussion

The structure of the feeding instars of *Profenusa alumna* is very similar to that of the other fensine larvae (see Lorenz and Kraus, 1957, for comparisons), all being adapted for mining leaves. Perhaps the most obvious differences are the absence of prolegs and the shorter, weaker thoracic legs, without claws. These legs are considered to have two segments instead of three as stated by Lorenz and Kraus for the genus. This is the smallest number of segments in any member of the tribe, wherein the range is usually three to five. When the legs are extended laterally the basal spines are brought in contact with the plant tissue where they possibly prevent the larva from slipping, thus performing partly the function

normally performed by the tarsal claws. The absence of ocelli in *P. alumna* seems also to be unique among the Fenusini.

In the final, non-feeding instar the shape of the larva and the mouth-parts have, for the most part, reverted to those of a more typical sawfly larva. Even here, however, the ocelli and prolegs are absent, and the thoracic legs are large and fleshy, and without claws. All these factors indicate that *P. alumna* may be the most highly specialized member of the Fenusini, a position different from that accorded it by Ross (1937) who suggests, on the basis of reduction of wing venation, that *Fenusa* shows the "ultimate reduction" (specialization).

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### A Key to the Larvae of Leaf-Mining Sawflies on Birch in Ontario with Notes on their Biology<sup>1</sup>

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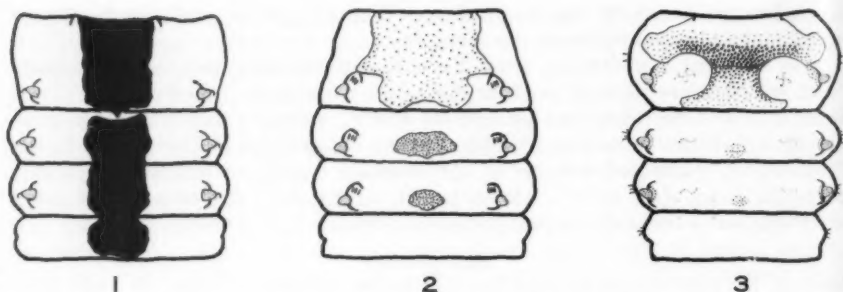
The larvae of leaf-mining insects are difficult to rear in the laboratory and large-scale insect surveys must often rely on the identification of immature stages for their information. The need for a larval key to the birch leaf-mining sawflies in Ontario became apparent when a complex of three species, *Profenusa alumna* (MacG.), *Fenusa pusilla* (Lep.), and *Heterarthrus nemoratus* (Fall.), was first discovered in 1955 (Lindquist 1955). Larvae of the three mentioned species have been described in recent years by Watson (1959), Friend (1933), and Peirson and Brower (1936), respectively. Additional descriptions of the larvae of *F. pusilla* and *H. nemoratus* were made by Daviault (1937). Information on distribution and seasonal occurrence was obtained from collections made by forest biology rangers over a 3-year period. Brief notes on the biology of the species, for comparison purposes, follows the larval key.

#### Key to the Larvae

Larvae associated with adults identified by the Systematic Entomology and Biological Control Unit, Ottawa, were studied. The resulting key was tested throughout three field seasons and was found adequate for identifying all samples received, including those containing only exuviae.

1. Thoracic legs with claws; black midventral stripe on thoracic and first abdominal segments of intermediate stages (Fig. 1) ..... *Fenusa pusilla* (Lep.)
- Thoracic legs without claws; large yellow or brown ventral patch on prothorax and small midventral patches on other thoracic segments of intermediate stages (Figs. 2 and 3). .... 2

<sup>1</sup>Contribution No. 509, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.



Figs. 1-3. Ventral view of thoracic segments and the first abdominal segment of the last feeding stage of three birch leaf-mining sawflies; Fig. 1 *Fenusa pusilla* (Lep.), Fig. 2 *Profenusa alumna* (MacG.), Fig. 3 *Heterarthrus nemoratus* (Fall.).

2. Conspicuous dark spines usually three in number at the base of each thoracic leg (these spines lighter and less conspicuous on mature larvae); no ventral eversible aids to locomotion on thorax (Fig. 2). ..... *Profenusa alumna* (MacG.)  
 No dark spines at base of each thoracic leg; pairs of ventral eversible aids to locomotion on thorax, prothoracic pair being most conspicuous (Fig. 3) ..... *Heterarthrus nemoratus* (Fall.)

#### *Profenusa alumna* (MacG.)

A single generation each year occurs in central Ontario (Martin and Watson) and there is no indication of a second generation even in the southern districts. It is the most common species of the complex. Over the three-year period larvae were found in the mines from July 15 to October 1. A preference for mature foliage at low levels on the tree is evident, although mining at higher levels also occurs particularly when the insect is abundant. The full-grown larva vacates its mine to pupate in the soil. This sawfly is found from the Quebec border west to White River, and from Kapuskasing in the north to Lake Erie in the south. It is the most northerly of the three species and occurs only at scattered locations in the southern part of the province. Host trees are *Betula papyrifera* Marsh., *B. lutea* Michx.f., and *B. populifolia* Marsh.

#### *Fenusa pusilla* (Lep.)

Two or three generations occur each year in Quebec depending on the type of host stand (Davault 1937), and a similar situation is indicated in Ontario. Larvae were collected from May 25 to October 1. As noted by other workers this species shows a strong preference for young leaves and consequently in the later generations mining is more prevalent on the new growth of sprouts and in the periphery of the host-tree crowns. The mined leaves tend to become wrinkled. The full-grown larva drops to the ground to pupate in the soil. This species is more restricted in distribution within the province than is *P. alumna*, and is found in the area from the Quebec border west to Sudbury and from the Lake Nipissing region in the north to Lake Erie in the south. The host trees for this insect are: *Betula papyrifera* Marsh., *B. lutea* Michx.f., *B. populifolia* Marsh. in the limited area in which the latter occurs in southeastern Ontario, and the introduced European species *B. alba* L. and its varieties.

#### *Heterarthrus nemoratus* (Fall.)

A single generation per year occurs in Ontario and larvae were collected from mid-August (Davault 1937, reports larvae in July), until the leaves were

shed in the fall. It is the least common of the three species. Eggs are laid on mature foliage, apparently at any level on the tree. Distinctive characteristics of *H. nemoratus* are the relative absence of frass in the mine and the larval hibernaculum spun in the leaf mine. This species is currently known to be present in five widely separated localities throughout the general range of *P. alumma*. It was recorded previously in southern Ontario by Raizenne (1957). The host trees are: *Betula papyrifera* Marsh., and *B. lutea* Michx.f.

#### Acknowledgments

I wish to express my appreciation to Mr. J. L. Martin for his advice in the preparation of the manuscript. I wish also to thank Dr. W. C. McGuffin, Forest Biology Laboratory, Calgary, Alta., for his suggestions regarding the arrangement of the key.

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### *Niptus* Boield. and Allied Genera in North America (Coleoptera: Ptinidae)

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This paper offers a taxonomic treatment of the North American species of the genera *Niptus* Boieldieu (1856, pp. 290, 662), *Epauloeus* Mulsant and Rey (1868, pp. 49, 198), and *Pseudeurostus* Heyden (1906, p. 424), which was proposed as a new name for *Eurostus* Mulsant and Rey, 1868, not Dallas, 1851. Six species are considered. Two of these are treated in Fall's revision of the North American Ptinidae (1905, pp. 107-108). Two others are Old World species that were discovered more recently in Canada, and two species are described as new. All of the species belong to *Niptus* in the sense of Fall's revision, which this paper supplements. Three of the six species are imported minor pests and are known in America only from buildings, where they breed in organic matter of various kinds. The others are native, outdoor species of the western United States. Hinton (1941, pp. 339-344) has described and figured the pest species and has summarized the literature on their habits.

The genera, which are characterized in the following key, have the following characters in common. Antennae of eleven segments. Eyes relatively small. Pronotum with a strong subbasal constriction, the portion before the constriction globose. Scutellum indistinct. Elytra more or less globose; their punctures in rows; their sides strongly and evenly rounded; lacking umbones. Hind trochanters attaining the margins of the elytra. Body form varying little or not at all sexually.



The taxonomic history of the native species and the known American distribution of all species is covered completely in the references and notes given with the descriptions below. Additional references to the introduced species are given by Pic (1912) and by Hinton (1941).

### Key to Genera and Species

1. Front flattish between the antennal fossae, its width there at least half as great as the length of the first antennal segment ..... 3  
 Front almost cariniform between the antennal fossae, its width there not more than one-quarter as great as the length of the first antennal segment. Femora gradually enlarged apically, their upper margins near middle almost straight. Vestiture consisting entirely of fine hairs, not completely concealing the integument except on the middle tibiae apically (*Pseudeurostus* Heyden) ..... 2
2. Each elytral interval with close, recumbent hairs and with a single row of semierect hairs. Pronotum shining, usually as strongly so as the elytra. Each intermediate antennal segment four-fifths as wide as long. An outdoor species ..... 1. *Pseudeurostus kelleri* n.sp.  
 Each elytral interval with a row of semierect hairs, lacking other vestiture. Pronotum subopaque, much duller than the elytra. Each intermediate antennal segment two-thirds as wide as long. A domestic species ..... 2. *Pseudeurostus hilleri* (Reit.)
3. Femora gradually enlarged apically, their upper margins near middle almost straight. Vestiture consisting entirely of hairs, not completely concealing the integument except on the middle tibiae apically. (*Epauloecus* Muls. and Rey) ..... 3. *Epauloecus unicolor* (Pil. and Mitt.)  
 Femora suddenly enlarged apically, their upper margins near middle sinuate. Vestiture consisting in part of small, appressed scales, which conceal at least the integument of the head, antennae in part, body beneath, and legs (*Niptus* Boield.) ..... 4
4. Golden throughout, the colour given by the scales, which conceal the integument of the entire insect. Hairs of the pronotum not forming tufts. A domestic species ..... 6. *Niptus hololeucus* (Fald.)  
 Brown above; the elytra lacking scales except on the external interval of each, with hairs which do not conceal the integument. Hairs of the pronotum forming a transverse row of four tufts before the subbasal constriction. Outdoor species ..... 5
5. Width of each eye fully as great as the width of the second antennal segment. Elytra at middle with each interval not or scarcely twice as wide as a striae puncture ..... 4. *Niptus ventriculus* Lec.  
 Width of each eye equal to half the width of the second antennal segment. Elytra at middle with each interval, except the first, about four times as wide as a striae puncture ..... 5. *Niptus abditus* n.sp.

### 1. *Pseudeurostus kelleri*, new species

Length 2.5 to 3.5 mm. Integument very dark reddish-brown. Vestiture consisting entirely of fine, golden hairs; the hairs not completely concealing the integument except on the middle tibiae apically.

Head very finely and densely alutaceous, subopaque; the vestiture moderately close. Eyes very slightly longer than wide, the width of each distinctly greater than that of the second antennal segment. Antennae stouter than in *hilleri*, two-thirds as long as the body; segments four to ten equal, the width of each equal to four-fifths the length.

Pronotum not alutaceous, shining; finely and closely granulate except near the anterior margin at middle. Pronotal hairs only moderately close but closer than in *hilleri*; inclined; in perfect specimens the hairs on each side immediately behind the middle directed to a common point but not forming tufts.

Elytra similar in form in the sexes, their width about 68 per cent as great as their length. Elytral striae not impressed; each consisting of a row of



moderately coarse punctures; each puncture bearing a recumbent hair on its anterior margin; these hairs longer than in *hilleri*, the length of each subequal to the width of an elytral interval. Elytral intervals flat, polished; each about three times as wide as a stria puncture; each supplied with a row of semierect hairs and with recumbent hairs; the latter not arranged in series but with the density that would be provided by three very irregular rows. All hairs of the elytra similar in length and thickness.

Body beneath and femora with the vestiture closer and more conspicuous, otherwise as in *hilleri*. Secondary sexual characters not evident.

*Holotype*.—♂; 60 feet inside the entrance of Logan Cave (15 miles north of Logan), Cache Co., Utah; Aug. 23, 1953 (J. R. Keller); in the collection of the University of Utah.

*Paratypes*.—eight, same data as holotype; three, same locality and collector, Feb. 22, 1953; in the collection of the University of Utah and (type no. 6915) in the Canadian National Collection.

## 2. *Pseudeurostus hilleri* (Reitter)

*Niptus Hilleri* Reitter, 1877, p. 378.

*Eurostus hilleri*, Howe, 1940, p. 73; Hinton, 1941, p. 343, Fig. 9; Brown, 1944, p. 9.

*Eurostus alienus* Brown, 1940, p. 119.

Length 2.0 to 3.0 mm. Integument a medium reddish-brown. Vestiture consisting entirely of fine, golden hairs; the hairs not concealing the integument except on the apical halves of the middle tibiae.

Head very finely and densely alutaceous, subopaque; the vestiture moderately close. Each eye slightly longer than wide, the width equal to that of the second antennal segment. Antennae two-thirds as long as the body; segments four to ten equal, the width of each equal to two-thirds the length.

Pronotum very finely alutaceous, subopaque; with rather obscure, coarse punctures, the margins of which are scarcely elevated except near the lateral declivities where fine granules are evident. Pronotal hairs sparse, semierect, not forming even a suggestion of tufts.

Elytra usually slightly wider in females than in males, their width from 69 to 80 per cent as great as their length. Elytral striae very fine, scarcely impressed, finely punctate; each puncture bearing a recumbent hair on its anterior margin. Elytral intervals flat, polished; each several times as wide as a stria puncture and supplied with a single row of hairs, which are semierect and about twice as long as the stria hairs.

Body beneath and femora with the hairs closely appressed. Abdomen and metasternum with coarse, feebly impressed punctures, which are separated by distances equal to or greater than their diameters; apical half of abdomen densely, and the anterior parts very closely, microscopically punctulate. Apical segment of male with several long hairs arising from a coarse puncture on each side.

This species was described originally from Japan. It was first taken in Canada in 1936; although it is found infrequently, it had been taken in warehouses in four provinces by 1940. It was reported abundant in 1939 in warehouses in Scotland by Howe (1940, p. 73) and in 1940 in England by Hinton (1941, p. 344). It has not been reported from other countries. It is represented in the Canadian National Collection by specimens from: Fredericton and St. John, NEW BRUNSWICK; Quebec Windsor Mills, and Montreal, QUEBEC; Ottawa, ONTARIO; Lethbridge, ALBERTA; Kamloops, Vancouver, and Victoria, BRITISH COLUMBIA.

### 3. *Epauloecus unicolor* (Piller and Mitterpacher)

*Prinus unicolor* Piller and Mitterpacher, 1783, p. 67, Pl. 7, Fig. 7.

*Epauloecus unicolor*, Brown, 1940, p. 118; 1944, p. 9.

*Tipnus unicolor*, Hinton, 1941, p. 339, Fig. 6.

Length 2.1 to 2.8 mm. Integument a medium reddish-brown. Vestiture consisting entirely of moderately coarse, golden hairs; the hairs not completely concealing the integument except on the middle tibiae apically.

Head very finely and densely alutaceous, subopaque; the sculpture obscured by the close vestiture. Eyes nearly twice as long as wide, the width of each equal to that of the second antennal segment. Antennae three-fifths as long as the body; segments four to ten equal, the width of each equal to two-thirds the length.

Pronotum closely and roughly sculptured, moderately coarsely punctate and subgranulate, shining. Pronotal hairs moderately close, somewhat obscuring the sculpture, inclined; in perfect specimens, the hairs directed to a common line on each side of the median line and toward a common point on each side immediately before the subbasal constriction, these latter forming a false tuft on each side because of the tumidity of the pronotal disk there.

Width of the elytra from 71 to 82 per cent as great as the length. Elytral striae scarcely impressed; each consisting of a row of very coarse, deep punctures; each with a row of recumbent hairs. Elytral intervals feebly convex, polished; each only slightly wider than a stria puncture; each supplied with a row of semierect hairs and with recumbent hairs; the latter not in series but with the density that would be provided by two very irregular rows. All hairs of the elytra equal in length, the length of each subequal to the width of an interval.

Body beneath and femora with the hairs closely appressed; metasternum and abdomen with coarse, feebly impressed punctures and very finely punctulate as in *Pseudeurostus billeri*; the underside lacking sexual characters.

This species is native to Europe. It is known elsewhere only from three specimens taken in 1938 from warehouses at Truro, Nova Scotia, and at St. John and Fredericton, New Brunswick.

### 4. *Niptus ventriculus* LeConte

*Niptus ventriculus* LeConte, 1859, p. 13; Fall, 1905, p. 107.

*Niptus ventriculus*, Gorham, 1883, p. 196.

Length 2.3 to 3.0 mm. Integument a medium reddish-brown. Vestiture golden; consisting of hairs and small, appressed, elongate scales, which conceal the integument on the head, antennae, body beneath, legs, and on part of the external interval of each elytron.

Head with very elongate scales, which are similar to those of *abditus*. Eyes relatively large, the width of each equal to seven-tenths its length and a trifle greater than the width of the second antennal segment. Each antenna two-thirds as long as the body; segments four to ten subequal, the width of each fully as great as three-quarters of the length; the antennal vestiture as in *abditus*.

Pronotum roughly sculptured, moderately coarsely punctate and subgranulate as in *abditus*. Pronotal vestiture of coarse, flattened, inclined hairs; these obscuring the sculpture, forming a transverse row of four tufts immediately before the subbasal constriction; the outer tufts usually larger than the inner; usually a few scales near the anterior pronotal margin; the vestiture as in *abditus* but with the hairs a trifle less coarse.

Elytra similar in form in the sexes, their width from 77 to 82 per cent as great as their length, their form as in *abditus*, their vestiture consisting of fine

hairs. Elytral striae not impressed, each consisting of a row of punctures; the punctures coarse at the elytral base, becoming fine near the apex; each puncture with a recumbent hair on its anterior margin. Elytral intervals flat, polished, each subequal in width to a striaal puncture at base, about four times as wide as a striaal puncture at the summit of the apical declivity; each with a row of recumbent hairs, which are like those of the striae; the intervals with erect hairs also; these nearly twice as long as the recumbent hairs, lacking on the second interval and largely or entirely lacking on the fourth, arranged in a single row on each of the others, sparse throughout but more numerous near the base and apex of the elytra.

Abdomen with fine, sparse, recumbent hairs in addition to the appressed scales; metasternum and femora virtually lacking such hairs. Femora and tibiae much less slender than in the other species of *Niptus*. Secondary sexual characters not evident.

This species occurs from Utah to Texas and southern California. It has been reported doubtfully from Mexico and Guatemala by Gorham. It has been taken at Dugway (Little Granite Mountain, Tooele Co.), UTAH; Deming (4300 ft.) and Sante Fe (the type specimen), NEW MEXICO; Davis Mountains (Modero Canyon) and Marfa (4600-4800 ft.), TEXAS; Winslow, ARIZONA; Thousand Palms and Los Angeles, CALIFORNIA.

The species probably breeds in the nests of rodents. It was taken in large numbers from the nest of the wood rat *Neotoma* at Dugway in January by D. M. Allred. J. E. H. Martin took two specimens from the fur of a live-trapped kangaroo rat, *Dipodomys deserti* Stephens, at Thousand Palms in March.

#### 5. *Niptus abditus*, new species

Length 2.6 to 3.5 mm. Integument a medium reddish-brown. Vestiture golden; consisting of coarse and fine hairs and small, elongate, appressed scales, which conceal the integument on the head, antennae, body beneath, legs, and on the external interval of each elytron.

Scales of the head mostly about five times as long as wide. Eyes very small; each twice as long as wide, the width equal to half the width of the second antennal segment. Each antenna two-thirds as long as the body; the subapical segments twice as long as wide, the segments stouter basally; segment one with scales much like those of the head; segments two to six with much smaller scales and with coarse, flattened, inclined hairs; segments seven to eleven with very fine, dense, appressed hairs.

Pronotum roughly sculptured, moderately coarsely punctate and subgranulate, shining. Pronotal vestiture of coarse, flattened, inclined hairs; these obscuring the sculpture, forming a transverse row of four tufts immediately before the subbasal construction; the outer tufts usually larger than the inner.

Elytra similar in form in the sexes, their width about 75 per cent as great as their length; the vestiture consisting of fine hairs. Elytral striae not impressed; each consisting of a row of rather fine punctures; each puncture bearing a recumbent hair on its anterior margin. Elytral intervals flat, polished; each about four times as wide as a striaal puncture; each with recumbent hairs and, except for the second and fourth, with a row of erect hairs; the recumbent hairs not in series but with the density that would be provided by from one to two irregular rows, equal in length to the striaal hairs and two-thirds as long as the erect hairs.

Metasternum and abdomen with scales and with inconspicuous, coarse, flattened hairs; femora with scales only; all vestiture of these parts appressed. Legs moderately slender. Secondary sexual characters not evident.

*Holotype*.—30 feet inside the entrance of Spider Cave, Stansbury Island, Great Salt Lake, Utah; Nov. 29, 1952 (J. R. Keller); in the collection of the University of Utah.

*Paratypes*.—seven, same data; in the collection of the University of Utah and (type no. 6916) in the Canadian National Collection.

#### 6. *Niptus hololeucus* (Faldermann)

*Ptinus hololeucus* Faldermann, 1835, p. 214, Pl. 7, Fig. 6.

*Niptus hololeucus*, Boieldieu, 1856, p. 664; Fall, 1905, p. 108; Gibson, 1924, pp. 74-76; Brown, 1940, p. 118; Hinton, 1941, p. 340, Fig. 7.

Length 3.4 to 4.5 mm. Integument pale reddish-brown but concealed on the entire body and on all appendages by golden vestiture, which consists of fine hairs and scales; the scales lacking only on the eyes and the apical segments of each antenna, appressed, very small, elongate; each scale cleft to its middle.

Head with the hairs appressed. Eyes small, the width of each equal to two-thirds its length and to three-fourths the width of the second antennal segment. Each antenna two-thirds as long as the body; segments four to ten subequal, each twice as long as wide; segments nine to eleven with very fine, dense, appressed hairs; the other segments with fine, moderately long, inclined hairs.

Pronotal hairs moderately close, inclined or erect, not forming even a suggestion of tufts, those near the anterior margin directed toward the median line.

Width of the elytra from 71 to 81 per cent as great as the length. Elytral striae not impressed; each indicated by a row of inclined hairs, which are about half as long as those of the intervals. Elytral intervals flat; their hairs semierect, arranged in a single row on each.

Metasternum, abdomen, and femora with rather sparse, fine, inclined hairs in addition to the scales; legs very slender, the underside lacking sexual characters.

This species is said to be nearly cosmopolitan but absent in the tropics. It was first taken in North America at Halifax in 1899. It is taken infrequently in households, mills, and warehouses in Canada and northern United States and has been found at: Boston, MASSACHUSETTS; Butte, MONTANA; Charlottetown, PRINCE EDWARD ISLAND; Halifax, NOVA SCOTIA; St. John, NEW BRUNSWICK; Montreal and Longueuil, QUEBEC; London, ONTARIO; Dodsland, Moose Jaw, and Saskatoon, SASKATCHEWAN; Calgary, ALBERTA; Fernie, Kamloops, Vancouver, and Victoria, BRITISH COLUMBIA.

#### Summary

Six species belonging to *Niptus*, *Epauloecus*, and *Pseudeurostus* are keyed and described. Two of the species, *Niptus abditus* and *Pseudeurostus kelleri*, from Great Salt Lake and Cache Co., Utah, respectively, are described as new.

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### Notes on Life-History of the Onion Maggot, *Hylemya antiqua* (Meig.) (Diptera: Anthomyiidae), in Sandy and Organic Soils

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This is a report on field observations and experiments on the life-history of the onion maggot, *Hylemya antiqua* (Meig.), conducted from 1955 to 1958 in sandy and organic soils of southwestern Quebec. The dates of emergence of adults, the number of generations, the percentage of pupae entering diapause in each generation, and the relationship between diapause, air temperature, and precipitation were recorded.

#### Materials and Methods

Field experiments were conducted simultaneously in sandy soil at Rougemont and in organic soil at Ste. Clothilde approximately fifty miles apart. Onion seed was sown at each locality in three framed soil sections described by Lafrance and Perron (1955). The sections measured 10 feet long, four feet wide, and six inches deep, and were buried in the soil before seeding. One ten-foot row was seeded to onion, variety Early Yellow Globe, weekly from the end of April to the end of July, the rows being 17 inches apart. Each section was covered with an emergence cage (Lafrance and Perron, 1955) after the oviposition period of each generation, when the plants were three to four inches high. Onion sets were placed near the seedlings to provide ample food for the larvae.

Records were taken twice a week throughout the season. Adults were collected in the emergence cages and recorded. In the fall, pupae remaining in each soil section were collected through the floatation separator described by Lafrance and Perron (1956). The percentage of pupae entering diapause in each generation was calculated on the basis of the total number of pupae and adults collected from each section. Daily air temperature and precipitation were recorded throughout the season by means of a thermograph and a tilting bucket recording gauge.

#### Results and Discussion

*Dates of Emergence of Adults.* — During the four years, the first adults appeared in the field between May 11 and 26 (Table I), or when apple trees were in the pink bud stage. Observations by previous workers in Canada showed that the date of emergence varied slightly from region to region. At Ottawa,



TABLE I.  
Dates of emergence of adults of *H. antiqua* from pupae of various generations in two types of soil in southwestern Quebec, 1955-58.

Year	Sandy soil						Organic soil					
	Overwintered	First emergence		Peak of emergence		Overwintered	First emergence		Peak of emergence			
		First	Second	First	Second		First	Second				
1955	May 11	June 25	Aug. 16	July 2	Aug. 22	May 13	June 26	Aug. 16	July 4	Sept. 6		
1956	May 26	July 9	Aug. 23	July 13	Sept. 5	May 28	July 3	Aug. 27	July 30	Sept. 5		
1957	May 13	July 2	Aug. 26	July 4	Aug. 26	May 13	July 2	Aug. 23	July 8	Aug. 26		
1958	May 20	July 2	Aug. 27	July 8	Sept. 4	May 28	July 9	Aug. 26	July 14	Aug. 26		



TABLE II.  
Percentage of pupae of each generation of *H. antiqua* entering diapause in two types of soil, in field cages, in southwestern Quebec, 1955-58

Year	Dates onion sown	Period covered with emergence cages	Sandy soil			Organic soil		
			Adults collected	Pupae collected	Percentage pupae in diapause	Adults collected	Pupae collected	Percentage pupae in diapause
1955	May 2, 9, 16	First Generation June 23 until fall June 28 until fall June 28 until fall June 27 until fall Mean	415	0	0	366	0	0
1956	Apr. 30, May 7, 14		295	24	8	435	178	29
1957	Apr. 29, May 6, 13		270	6	2	316	127	29
1958	Apr. 28, May 5, 12		802	25	3	249	60	20
		Mean			3			20
1955	June 6, 13, 20	Second Generation First week of May to June 28. Aug. 10 until fall Mean	223	48	18	135	49	27
1956	June 4, 11, 18		22	178	89	45	390	90
1957	June 3, 10, 17		16	132	89	147	267	65
1958	June 2, 9, 16		49	382	89	5	51	91
		Mean			71			68
1955	July 11, 18, 25	Third Generation Covered after seeding. Uncovered from Aug. 11 until fall Mean	0	1307	100	0	622	100
1956	July 9, 16, 23		0	609	100	0	2834	100
1957	July 8, 15, 22		0	740	100	0	625	100
1958	July 7, 14, 21		0	331	100	0	605	100
		Mean			100			100

Ont., Gibson and Treherne (1916) observed the flies in numbers in the third week of May. Armstrong (1924) reported the first fly from the Montreal district on May 20 in 1923. Treherne and Ruhmann (1922) stated that at Vernon, B.C., the first adults appeared between May 10 and May 15 in 1921, when the onions were one to  $1\frac{1}{2}$  inches high. Gray (1924) observed the first adults in Alberta on May 15 in 1923. Kendall (1932) stated that, in Ontario, flies were observed on May 31 in 1929, on May 9 in 1930 and May 20 in 1931, or when peach blossoms have fallen, dandelions have just bloomed and apple trees are in the pink.

Adults of the first generation emerged between June 25 and July 9, and those of the second generation between August 16 and 27 (Table I). The peak of emergence of the first generation occurred the first or second week of July except in organic soil in 1956, when it was at the end of July; of the second generation, on the last week of August or the first week of September. The dates of peak of emergence varied somewhat from year to year, but usually occurred during periods of temperature higher than average. Armstrong (1924) reported for 1923 that adults from the second generation emerged in the Montreal district between July 4 and 10 and those from the third generation appeared in rearing vials on August 21. Armstrong's second and third generation adults are referred to in this paper as first and second generation adults, the first generation beginning with eggs laid by adults emerging from overwintered pupae.

*Number of Generations.* — There were three generations each year, some of the pupae entering diapause in each generation except in 1955 (Table II). Hammond (1924) reared two complete generations and some adults of a third in field cages in 1923 in the Ottawa district.

*Percentage of Pupae Entering in Diapause in Each Generation.* — From 1956 to 1958, the percentage of first-generation pupae that entered diapause in sandy soil was 2 to 8 and for the second-generation, 89; in organic soil, 20 to 29 and 65 to 91; in both soil types, for the third generation, 100 (Table II). However, in 1955, no pupae entered diapause in the first generation and only 18 and 27 per cent in the second generation in sandy and organic soils respectively. During the four years, a significantly lower percentage of first-generation pupae entered diapause in sandy than in organic soil, or 3 against 20. Hammond (1924) observed in 1923 that 87 per cent of the pupae remained in diapause in the second-generation. Armstrong (1924) reported for 1923 that 81 per cent of the second-generation pupae hibernated.

*Relationships between Diapause, Air Temperature and Precipitation.* — The average temperatures for May, June, July and August in 1955 were several degrees higher than for 1956 to 1958 (Table III). In 1955, the percentages of pupae entering diapause in the first and second generations were much lower than in the subsequent three years (Table II), and the adults began emerging over a week earlier in every generation (Table I), suggesting that the higher temperature accelerated pupal development and hastened the date of emergence of flies. When the average temperature during pupation was over 70° F. fewer pupae entered diapause. No such association could be established with the precipitation records. Miles (1955) observed that the number of second-generation flies was negligible in 1953 at Wye. She (1958) reported that diapause in the pupal stage was not obligatory, since rearing at 25° C. produced four complete generations whereas diapause occurred at lower temperature. Perron *et al.* (1953) reported that, when the insect was reared in indoor cages during

TABLE III.

Average monthly air temperatures and precipitation in southwestern Quebec,  
from May to September 1955-58

Month	Air temperature °F.				Precipitation inches			
	1955	1956	1957	1958	1955	1956	1957	1958
May.....	59	51	53	49	2.11	3.38	2.85	2.35
June.....	69	66	66	57	1.78	3.40	3.83	3.46
July.....	75	66	69	66	2.60	3.70	4.30	9.50
August.....	73	66	65	63	5.09	2.90	0.20	4.40
September.....	56	51	59	56	2.67	2.10	3.92	4.24
Mean.....	66	60	62	58	2.9	3.1	3.0	4.8

the winter months, the majority of the pupae entered a dormancy that was easily broken, whether or not they were exposed to freezing temperature.

#### Summary

Field studies on *Hylemya antiqua* from 1955 to 1958 in sandy and organic soils of southwestern Quebec indicated that the adults earliest emerged from overwintered pupae between May 11 or 26, or when apple trees were at the pink bud stage. In both soil types, adults of the first generation emerged between June 25 and July 9, the peak of emergence being in the first or the second week of July; adults of the second generation emerged between August 16 and 27, the peak of emergence being in the last week of August, or the first week of September. There were three partial generations a year in 1956 to 1958, but the first generation was complete in 1955. During the four years, in sandy soil three per cent of the first-generation pupae entered diapause, 71 per cent of the second, and 100 per cent of the third; in organic soil, 20 per cent of the first, 68 of the second and 100 per cent of the third. When the average temperature during pupation was over 70° F. fewer pupae entered diapause. Higher average monthly temperature accelerated pupal development and hastened the emergence of flies.

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### Some Aphids from Bermuda (Homoptera)<sup>1</sup>

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Ogilvie (1927) lists five aphids of economic importance from Bermuda; namely, *Illinoia* (*Macrosiphum*) *solanifolii* (Ashm.) (= *Macrosiphum euphorbiae* (Thom.)), *Myzus persicae* (Sulz.), *Aphis lillii* Takah., *Aphis gossypii* Glover, and ? *Fullawayella formosana* Takah. (possibly *Neotoxoptera formosanus* (Takah.) or *N. violae* (Pergande)). Later, in 1928, he states that the species formerly identified as *Aphis lillii* Takah. was *Aphis gossypii* Glover and records eighteen additional species from Bermuda. The slides of these specimens presumably are in the British Museum (Natural History) since Mr. F. Laing and Mr. F. V. Theobald identified the aphids.

Between October, 1956, and March, 1957, Mr. P. W. Vroom<sup>2</sup> and Mr. A. G. Dustan<sup>3</sup> made some sixty collections of aphids in Bermuda and also collected, whenever present, associated parasites. They collected fifteen aphid species although only seventeen of some 250 plants which Groves (1955) lists for Bermuda were sampled. Here, I list alphabetically according to genus these fifteen aphid species and, because of the changes in nomenclature, those species recorded by Ogilvie (1928). The land area of Bermuda is only about twenty square miles so the locality of each collection is not given.

#### *Aphis* Linnaeus

*coreopsidis* Thomas.—Apterous viviparous females were collected from *Bidens pilosa*, November 30, 1956.

*fabae* Scopoli.—Apterous viviparous females were collected from *Tropaeolum majus*, November 23 and December 12, 1956. Ogilvie (1928) lists *Aphis ogilviei* Theobald sp. nov. and it was described in the same bulletin by Theobald (1928). According to information received from Mr. J. P. Doncaster, British Museum (Natural History) this species looks suspiciously like *Aphis fabae* Scop. and undoubtedly is one of the "Black Aphid" complex.

*gossypii* Glover.—This species was by far the most common in the collections. According to Ogilvie (1928) he had shown that it is the vector of "yellow flat" an important virus disease of lilies. Collections were made between November 2, 1956, and January 23, 1957, on *Acalypha wilkesiana*, *Bidens pilosa*, *Bougainvillea* sp., *Bryophyllum* sp., *Coccoloba uvifera*, *Duranta repens*, *Echeveria* sp., *Eriobotrya japonica*, *Hibiscus rosa-sinensis*, *Lilium longiflorum* varieties, *Saint-*

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*paulia ionantha*, *Sida carpinifolia*, *Tabebuia pallida*, and *Tecoma capensis*. Usually the plants were heavily infested, particularly the young twigs and leaves. On *Lilium longiflorum* the aphids colonized between the spear-like upper leaves of the plants. On *Bryophyllum* the infestation occurred inside the pod like structure which is the flower.

*nerii* B. d. F.—Apterous and alate viviparous females were collected from *Asclepias* sp., *Nerium oleander* and *Pereskia aculeata* between October 17 and December 18, 1956.

*spiraecola* Patch.—Alate and apterous viviparous females were collected between November 1 and December 14, 1956, from *Acalypha godseffiana*, *Fumaria muralis*, *Ligustrum lucidum*, *Polyscias balfouriana*, *Senecio confusus*, *Solidago sempervirens*, and *Viburnum suspensum*. An oviparous female was in the collection from *Senecio confusus*. This may be the species listed by Ogilvie (1928) as *Aphis pomi* DeGeer from *Eriobotrya japonica*. Mr. Hille Ris Lambers (in litt.) has pointed out to me that these species can be easily separated; for *Aphis pomi* DeGeer has marginal abdominal tubercles on segments I-IV and VII, whereas *Aphis spiraecola* Patch has marginal tubercles only on abdominal segments I and VII.

#### ***Asiphonella* Theobald**

*dactylonii* Theob.—Ogilvie (1928) records this species from Bermuda grass (*Cynodon dactylon*). Eastop (1928) states that there is material of this species in the British Museum labelled, "Bermuda Agr. Exp. Sta. (No. 408), 10.12. 1924, coll. L. Ogilvie."

#### ***Brachycaudus* van der Goot**

*persicaecola* (Boisduval).—Ogilvie (1928) lists this species from peach as *Anuraphis persicae-niger* (Smith) which is, according to Börner (1952) and Eastop (1958), a synonym of *B. persicaecola*.

#### ***Brevicoryne* van der Goot**

*brassicae* (L.).—Ogilvie (1928) records this species from kale and cabbage.

#### ***Capitophorus* van der Goot**

*elaegni* (del Guercio).—This is possibly the species listed by Ogilvie as new, from *Cynara cardunculus*.

#### ***Carolinaia* Wilson**

*cyperi* Ainsley.—Alate and apterous viviparous females were collected December 3, 1956, from *Cyperus esculentus*, one of the most noxious weeds in cultivated fields, and from *Lilium longiflorum*, November 29, 1956.

#### ***Cerataphis* Lichtenstein**

*lataniae* (Boisd.).—Ogilvie (1928) reports that this species had been recorded from palms in Bermuda.

#### ***Chomaphis* Mordwilko**

(*Dysaphis*) *apiifoliae* (Theob.) and *Chomaphis* (*Dysaphis*) *foeniculus* (Theob.).—These species were collected together from *Foeniculum vulgare* December 24, 1956. According to Mr. P. W. Vroom the colonies are well concealed and cannot be detected until the leaf blades are separated. The host is an escaped weed generally infested with aphids and is common along roadsides and waste places. Ogilvie lists *Anuraphis tulipae* (B. d. F.) (= *Chomaphis tulipae*) from the roots of parsley, carrots, turnips, celery, and marigolds.

Theobald (1927) records this species from parsley roots collected by L. Ogilvie, June 23, 1925, in Bermuda. According to Eastop (1958) most of the records of *Aphis tulipae* on *Umbelliferae* probably apply to other *Chomaphis* species such as *C. apiifoliae*, *C. crataegi* (Kltb.) and *C. foeniculus*.

**Eriosoma Leach**

*lanigerum* (Hausm.).—Ogilvie (1928) reports that this species was intercepted on plants from the Azores.

**Idiopterus Davis**

*nephrolepidis* Davis.—Ogilvie (1928) records this species from greenhouse ferns.

**Lipaphis Mordwilko**

*pseudobrassicae* (Davis).—Only a few apterous specimens were collected from seedlings of broccoli, red cabbage, green cabbage, kale and swiss chard, December 5, 1956. Ogilvie (1928) lists this species as *Aphis pseudobrassicae* Davis.

**Macrosiphoniella del Guercio**

*sanborni* (Gillette).—Alate and apterous viviparous females were collected from *Chrysanthemum* sp., October 13, November 6, 1956. Ogilvie (1928) also records this species.

**Macrosiphum Passerini**

*euphorbiae* (Thom.).—Ogilvie (1928) records this species as *Macrosiphum gei* (Koch.). Apterous viviparous females were collected November 30, 1956, from *Solanum tuberosum* and December 18, 1956, from *Ipomoea batatas*.

**Myzus Passerini**

*persicae* (Sulz.).—Alate and apterous viviparous females were collected from a mixture of broccoli, red cabbage, green cabbage, kale and swiss chard, and from *Ipomoea dissecta*, *Lilium longiflorum*, *Senecio confusus*, and *Solanum tuberosum* between November 27 and December 14, 1956.

**Nasonovia Mordwilko**

(*Hyperomyzus*) *lactucae* (L.).—Alate and apterous viviparous females were collected on January 8, 1957, from a heavy infestation on *Sonchus* sp.

**Pentalonia Coquerel**

*nigronevosa* Coq.—Ogilvie (1928) and Theobald (1926) record this species from Bermuda from banana (*Musa* spp.).

**Rhodobium Hille Ris Lambers**

*porosum* (Sanderson).—Apterous viviparous females were collected from *Rosa* sp., December 3, 1956, and January 3, 1957, and from *Senecio confusus*, December 14, 1956.

**Rhopalosiphum Koch**

*maidis* (Fitch).—Ogilvie (1928) lists this species as *Aphis maidis* Fitch from corn and *Panicum dichotomiflorum*.

*nymphaeae* (L.).—Ogilvie (1928) records this species from *Ruppia maritima*.

**Sipha Passerini**

*flava* (Fobes).—Alate and apterous viviparous females were collected from *Stenotaphrum secundatum*, March 8, 1957. Ogilvie (1958) records this species from grasses and sugar cane and states that it is very common.



**Toxoptera Koch**

*aurantii* (B. d. F.).—Alate and apterous viviparous females were collected between October 15 and December 12, 1956, from *Acalypha godseffiana*, *Bougainvillea* sp., *Catalpa longissima*, *Citrus* spp., *Coccoloba wuifera*, *Gardenia thunbergia*, *Hibiscus* sp., *Murraya paniculata*, *Pereskia aculeata* and *Pittosporum* sp. This species is apparently very common. Eastop (1958) states that Theobald's record of *Aphis taversi* del Guercio from Italian Somaliland was in error, the species being *T. aurantii*. Possibly this is also true of Ogilvie's (1928) record of *A. taversi*.

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## New Species and a New Subspecies of *Palpita* (Lepidoptera : Pyralidae)<sup>1</sup>

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Study of material of *Palpita* from a variety of sources has revealed the existence of numerous superficially similar species differing in striking characters of the genitalia. In this paper I describe certain species for which names are required at the present time. I hope when time permits to publish a full revision of the species of the genus.

***Palpita kimballi* new species**

Fig. 1

Body white, wings translucent white. Frons and maxillary palpus fulvous; labial palpus fulvous, narrowly white below; eye black; proboscis light brown. Dorsal surface of mid-tibia, anterior margins of patagium and tegula, and costal region of forewing above all fulvous. Forewing with two black dots in cell behind costa, another at anterior angle of cell, a fourth at posterior angle of cell; hind wing with a black dot at posterior angle of cell. Some or all of these dots are lost in individual specimens, those at posterior angle of cell being the most persistent. Anal tuft of male white, with a few blackish scales. Expanse 23-26 mm.

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Male genitalia. Vinculum dorsally with transverse anterior flange and a thin longitudinal carina. Tegumen domed; uncus weak, slender, slightly dilated at tip, with very weak anteriorly directed setae. Juxta T-shaped, posteriorly carinate, with a dorsal supplementary sclerite, bearing a comb of spines, longest dorsally. Valves broad and oval, with unlike armature: the left with a broad, halberd-shaped process from the sacculus, lying flat against the body of the valve, the right with a narrower, bicornuate process, twisted at right angles to the body of the valve. Aedoeagus with basal three-fourths membranous except for a sclerotized strap on one side; the distal fourth fully sclerotized. Vesica bearing a bunch of deciduous cornuti.

Female genitalia. Subgenital plate deeply incised, only narrow sclerotized straps remaining at side. Anterior lip of ostium strengthened by a tongue-like sclerotized flap. Bursa narrowly top-shaped, tapering to a rather blunt anterior end. Signa hollow, thorn-like, the left one wider and more flattened than the right.

Holotype, male, Englewood, Fla., Apr. 11, 1952, J. R. Vockeroth, and allotype, female, Siesta Key, Sarasota Co., Fla., May 16, 1946, C. P. Kimball; type no. 6172, C.N.C. A long series of paratypes from Siesta Key in Mr. Kimball's collection and in the C.N.C. One paratype, Miami, Fla., type lot no. 123, Carnegie Museum, Pittsburgh.

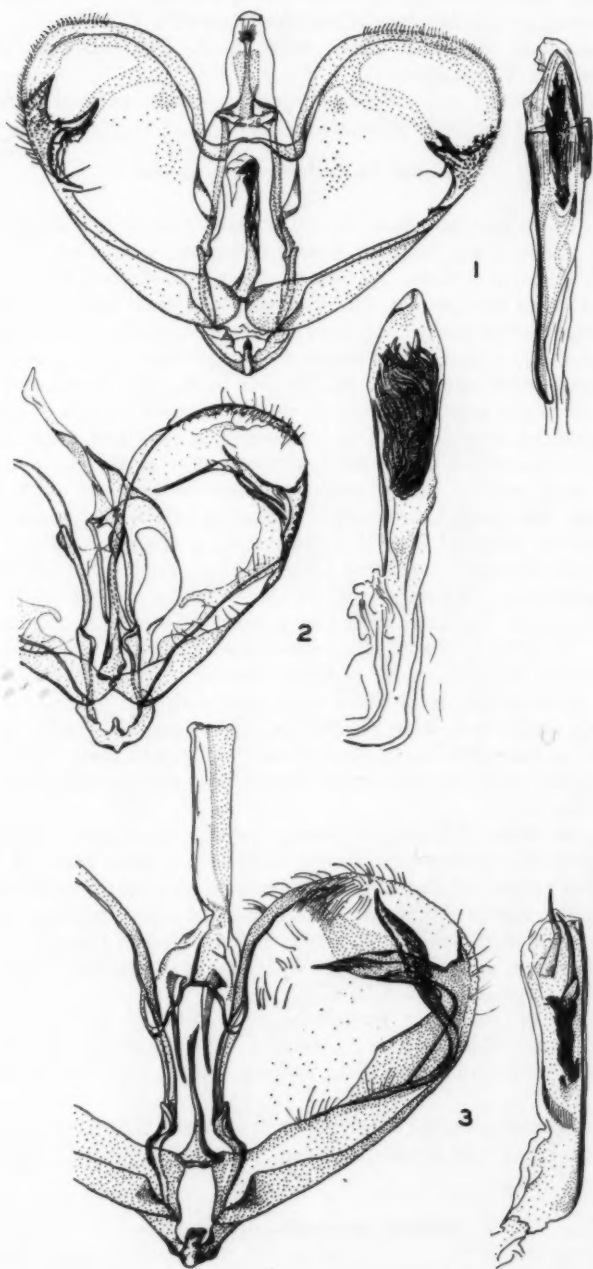
This small species, of West-Indian affinity, is easily recognized by the structure of the male genitalia. From *P. quadristigmatis* (Guenée), the only similar species of the genus known from Florida, it differs in its smaller size and pure-white coloration, the yellowish tints of *P. quadristigmatis* being absent.

#### *Palpita viettei*, new species

Fig. 2

Labial palpus with dorsal half ferrugineous, ventral half shining white; maxillary palpus ferrugineous; tongue and antenna white-scaled above; frons ferrugineous; vertex lemon-yellow, with a tuft of white scales at each occipital angle; postocular region ferrugineous; collar ferrugineous anteriorly and laterally, elsewhere white; tegula white with a ferrugineous stripe on humeral angle; legs mainly white, but with preaxial surface of fore femur and tibia and a ring at the distal end of these joints brown, and with restricted brown markings on the other legs; abdomen white. Forewing with outer margin oblique, apex acute; ground colour translucent white, costa with an even border of dull ferrugineous, tapering to a point at the apex; two black dots connected by a narrow black stripe adjacent to costal band in the cell; black dots at upper and lower angles of cell, the former touching the ferrugineous costal stripe, the costal stripe bordered by a black line from discocellular dot to apex; an obscure grey subterminal shade; terminal area and fringe opaque white; hind wing translucent white with a black dot at lower angle of cell; subterminal shade, terminal area and fringe as on forewing.

Male genitalia. Tegumen domed; uncus weak and short, with only a few setae at tip; valve broadly rounded; sacculus with a connate pair of dorsally directed spines near its distal end, the more medial spine extending nearly to the costal margin, first perpendicular to ventral margin, then bent at an angle of about 30 degrees and rapidly tapering; the external spine slightly and evenly curved, much shorter and more slender than the other spine, which entirely covers it; juxta normal; penis with two large fixed cornuti, and with a dense bundle of slender, deciduous ones.



Figs. 1-3. *Palpita* spp., ♂ genitalia. 1, *P. kimballi* Munroe; 2, *P. viettei* Munroe; 3, *P. forficifera* Munroe.

Holotype, male, Gourbeyre, Guadeloupe, French West Indies, June-July, 1952, L. Berland, in the Muséum d'Histoire Naturelle, Paris.

Paratype, male, Kenscoff, Haiti, 4826 ft., E. Ducasse, type lot no. 124, Carnegie Museum, Pittsburgh.

This species closely resembles the preceding one in external appearance, but differs obviously in the male genitalia.

***Palpita forficifera*, new species**

Fig. 3

White. Frons and maxillary and labial palpi rust-brown above, fuscous on sides; labial palpus white below. Antenna slender, tan-scaled. Vertex white, stained with greenish yellow. Patagium and tegula with a rust-brown lateral stripe. Fore femur rust-brown dorsally; basal and distal parts of fore tibia and the whole length of the fourth and fifth tarsal segments black on the preaxial surface. Wings thinly scaled, semitransparent, except near margins and along veins. Forewing above with costal area dull brown to  $R_4$ , the brown followed by a narrow opaque white zone. Two black dots at anterior margin of cell near base, another at anterior angle of cell and a fourth at posterior angle of cell. An obscure grey subterminal shade; black terminal dots at  $R_4$ ,  $R_5$ , and  $M_1$ . Hind wing above with a black dot at posterior angle of cell, and with a grey subterminal shade like that of forewing. Forewing below with costa much more narrowly brown; marginal dots elongated to form dashes parallel to costa, and more numerous, the series extending back to  $Cu_2$ . Expanse 23-30 mm.

Male genitalia. Vinculum with a well-marked dorsal carina; tegumen arched; uncus almost lost, represented by a short and inconspicuous stub. Rectal sclerite well developed. Juxta small, somewhat T-shaped, not carinate. Valve large and broad; sacculus thick, tapering distally, but bearing a dorsal flange from which arises at the distal end a large dagger-shaped process, which crosses scissors-wise a similar somewhat twisted process which arises independently from the distal end of the sacculus. Aedoeagus with a lateral heavily sclerotized strap; vesica armed with two irregularly rod-shaped fixed cornuti and with a bundle of deciduous cornuti.

Female genitalia. Ovipositor rather small; apophyses slender; seventh sternite trapezoidal, narrow posteriorly; ostium in a deep sinus of the seventh sternite, closed behind by the adjacent lobes of the sternite; ductus bursae short, unsymmetrically sclerotized; bursa broadest posteriorly, tapering anteriorly; a pair of long, slender, thorn-like signa near anterior end of bursa.

Holotype, male, and allotype, female, Nova Teutonia, Sta. Catharina, Brazil, F. Plaumann. Type no. 6176, C.N.C.

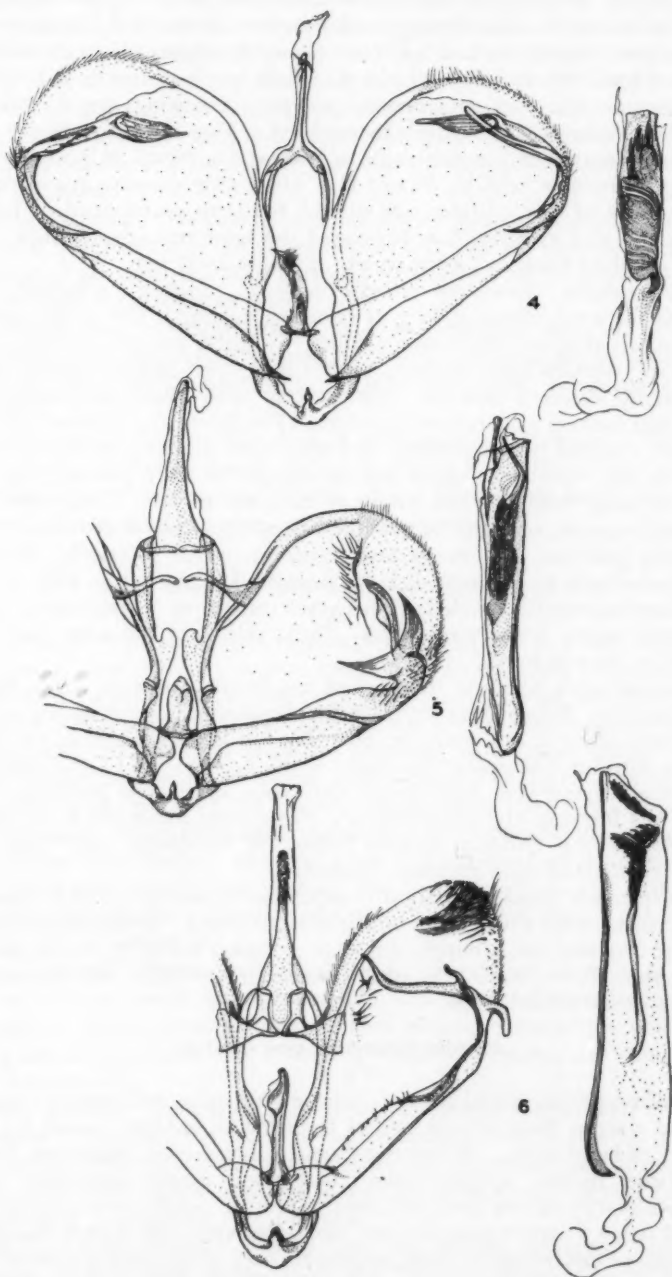
A number of paratypes from: the type locality (C.N.C.); Salesópolis, Boracea, São Paulo, Brazil, 850 m. (Ministry of Agriculture, Brazil); Prov. del Sara, Bolivia, 450 m.; and Buena Vista, Bolivia, 400 m., type lot no. 125, Carnegie Museum.

A robust species, closely resembling externally the following one, with which it flies, a little larger and broader winged, and with a distinct gray subterminal shade on both wings.

***Palpita persimilis*, new species**

Fig. 4

White. Frons and labial and maxillary palpi ferrugineous above, mixed ferrugineous and black on sides; labial palpus white below. Vertex mostly lemon-yellow. Antenna white at base, shading to light brown. Anterior and



Figs. 4-6. *Palpita* spp., ♂ genitalia. 4, *P. persimilis* Munroe; 5, *P. quadristigmatis* (Guenée); 6, *P. trifurcata* Munroe.

lateral margins of patagium and anterolateral margin of tegula ferrugineous. Thorax above and the more densely scaled parts of forewing lightly tinged with lemon-yellow. Dorsal surface of fore femur ferrugineous; basal and distal portions of fore tibia, end of third and the whole length of fourth and fifth foretarsal segments black on the preaxial surface. Forewing above with costa ferrugineous, followed by a darker brown band. Two black dots in cell behind costal band, another at anterior angle of cell, and a fourth at posterior angle. Black marginal dots at veins  $R_4$ ,  $R_5$  and  $M_1$ . Hind wing above with a black dot at posterior angle of cell. Under side similar, but with costal band of forewing narrower and with marginal dots attenuated and more numerous. Male with an anal tuft of mixed black and white scales. Expanse 23-27 mm.

Male genitalia. Vinculum dorsally carinate; tegumen moderately broad, domed; uncus weak, about as long as tegumen, bearing a few weak, anteriorly directed spines at apex. Juxta long, slender, T-shaped, carinate, dorsally spinose. Valve broad; sacculus large, bearing distally a long, fairly slender, sharply pointed, anterodorsally directed process. This process with distal end flattened, excavated, and bearing longitudinal striations. Parallel to this process and mesad of it arises a second process, slender and blunt, and differing on the two valves, that of the left valve being about half as long as the sharp process, that of the right valve being nearly the full length of the sharp process. Aedoeagus with a sharp fixed cornutus, obscured in most specimens by a mass of deciduous cornuti.

Female genitalia. Eighth sternite pyriform, broad anteriorly, deeply excavated posteriorly to accommodate the ostium. Ductus bursae very short and broad, unsymmetrically folded, heavily sclerotized in a reticulated pattern. Bursa short, hardly wider than ductus. Signa paired, of the usual thorn-shape, about half as long as bursa.

Holotype, male, allotype, female, and one female paratype, Nova Teutonia, Santa Catharina, Brazil, June 1953, Fritz Plaumann; several paratypes, same locality and collector; one paratype, Silvestre, Rio de Janeiro, Brazil; a series of paratypes, Boracea, Salesópolis, São Paulo, Brazil, type no. 6173 C.N.C. and in the collection of Ministry of Agriculture, São Paulo, Brazil; one paratype, Guadeloupe, in the Museum of Natural History, Paris; three paratypes, Prov. del Sara, Bolivia, 450 m., Las Quiguas, Esteban Valley, N. Venezuela, and "Costa Rica", type lot no. 126, Carnegie Museum, Pittsburgh.

This species is virtually identical in superficial appearance with *P. quadristigmatis* (Guenée), with which it has usually been confused. However, the genitalia of *P. quadristigmatis* are strikingly different, as shown in Fig. 5. I have seen true *quadristigmatis* from the U.S.A. and Mexico; further study will be needed to determine its southward range.

#### *Palpita trifurcata*, new species

Fig. 6

Maxillary palpus, dorsal part of labial palpus, sides and anterior margin of frons, and a stripe from eye to base of forewing all reddish brown; eye black; remainder of body white. Wings translucent white, faintly opalescent; forewing with a rather narrow reddish-brown costal stripe, darker posteriorly, of even width until shortly before apex, then tapering rather rapidly; immediately behind the costal stripe a narrow opaque white zone; forewing with minute black dot at lower angle of cell, absent in some specimens; both wings with a row of minute black dashes along and parallel to outer margin at ends of veins, the dashes always very small, almost lacking in some specimens, the anterior two or three of the forewing a little larger than the others.



**Male genitalia.** Uncus fairly well developed, its tip weakly spined but not dilated; tegumen fairly long; valve moderately expanded at tip, costa and sacculus rather broadly inflated, the latter ending in a slender, dorsally directed process giving off three mesally directed branches, one at ventral margin of valve, one at tip of process, and one in between; juxta of the usual shape and of moderate size; coremata fairly well developed; penis weakly sclerotized; vesica with a large sclerite and two rather numerous groups of short, straight cornuti, possibly deciduous.

**Female genitalia.** Ovipositor and apophyses weak; seventh sternite very broadly and quadrangularly emarginated posteriorly; ductus expanded, sclerotized and contorted at ostial end, then narrowly sclerotized; bursa slender, a pair of thorn-like signa near posterior end.

Holotype, male, allotype, female, and 39 paratypes, Boracea, Salesópolis, São Paulo, Brazil. Holotype, allotype, and a series of paratypes in collection of Ministry of Agriculture, São Paulo, Brazil. Remaining paratypes type no. 6818, C.N.C.

This species is closely related to *P. viriditinctalis* (Hampson), new combination (*Margaronia viriditinctalis* Hampson, 1918), but differs in having a three-pronged instead of a two-pronged process on the valve and in having the ground colour pure white, not light green as in *P. viriditinctalis*.

***Palpita isoscelalis goubeyrensis*, new subspecies**

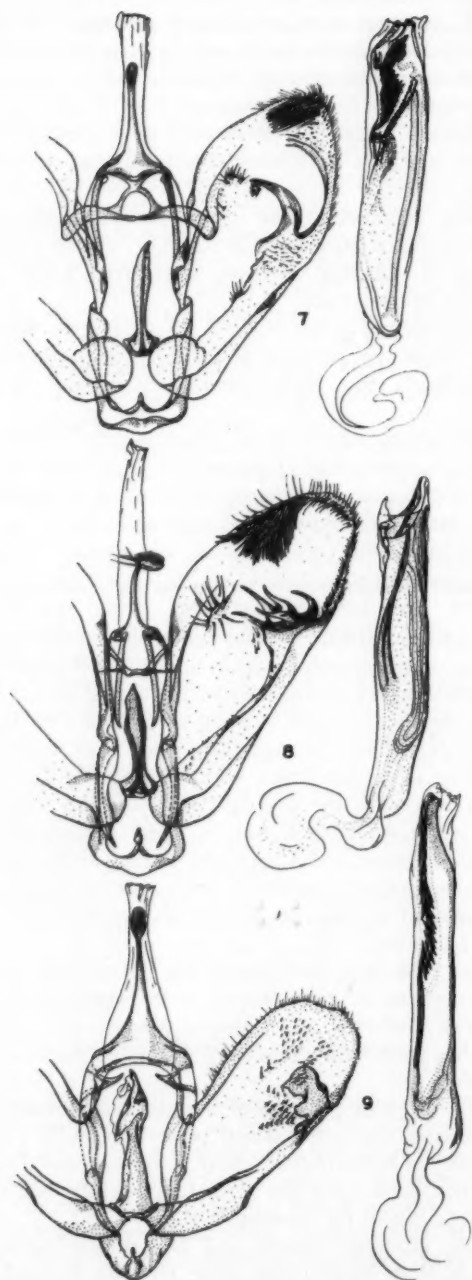
Fig. 7

Labial palpus with dorsal half fulvous, ventral half white; a dark lateral mark on the fulvous area; maxillary palpus, frons and a broad stripe from behind eye to below wing fulvous; vertex, remainder of body, and dorsal scaling of tongue and antenna white; legs white, with preaxial surface of fore femur fulvous and with distal half of fore tibia fuscous. Forewing with outer margin oblique, more so in male than in female; costa with a fulvous stripe, in two specimens clear, in the other two with the posterior half suffused with fuscous; ground colour translucent white; three black marginal dots, diminishing in size from apex backward; holotype, allotype, and a paratype without other markings except for a faint dark dot in cell adjacent to costal band; one paratype with two distinct black dots in cell adjacent to costal band and with two black dots on discocellular; hind wing white, unmarked.

**Male genitalia.** Uncus cylindrical, short, not dilated at tip, but with a small patch of short spines; valve ear-shaped, costa broadly dilated, sacculus bearing an oblique, distally directed, sickle-shaped process; juxta of the usual shape, very long and slender; penis with a bundle of deciduous cornuti and some obscure internal sclerotization.

**Female genitalia.** Female genitalia of the usual type; ostium with dorsal and ventral walls sclerotized, the latter armed posteriorly with a pair of hook-like flanges; ductus contorted behind ostial sclerites, first narrowed then dilated; bursa long and slender, the paired, hook-like signa long, slender and curved, unusually close together and unusually far proximad.

Holotype, male, allotype, female, and one female paratype, Goubeyre, Guadeloupe, French West Indies, June-July, 1952, L. Berland, in the Muséum d'Histoire Naturelle, Paris. One female paratype with the same data No. 6284 in the Canadian National Collection of Insects, Ottawa.



Figs. 7-9. *Palpita* spp., ♂ genitalia. 7, *P. isoscelalis gourbeyrensis* Munroe; 8, *P. braziliensis* Munroe; 9, *P. travassosi* Munroe.

This form is identical in genitalia with *Palpita isoscelalis isoscelalis* (Guenée), new combination (*Margarodes isoscelalis* Guenée), described from Brazil, but differs from the nominate subspecies in the great reduction of the dark markings of the forewing.

***Palpita braziliensis*, new species**

Fig. 8

Frons brown, fuscous on sides; vertex white; labial palpus fuscous, white at base beneath; antenna light brown, dorsally with light-brown scales in basal part and white ones in distal part; sides of head and lateral stripe from head to wing-base fuscous; remainder of body white. Wings translucent white. Forewing with outer margin strongly oblique and apex acute; costa broadly fuscous; two fuscous dots adjoining costal stripe in cell; small fuscous spots at upper and lower angles of cell, in some specimens faintly joined along discocellulars; a buff terminal line; two or three black terminal dots between veins behind apex; fringe white. Hind wing with buff terminal line as on forewing, otherwise unmarked. Wings beneath as above. Expanse 24-32 mm.

Male genitalia. Uncus narrow, weakly expanded and strongly spinose dorsally at tip; juxta rather narrow; valve with costa strongly bent at middle, a prominent tuft of scales on inner surface before apex; sacculus with a process bearing five or six spines, as illustrated; penis with a single elongate cornutus; culcitae rudimentary.

Female genitalia. Ovipositor normal; apophyses slender and weak; sclerotization of seventh sternite poorly defined, broadly heart-shaped, shallowly emarginated; ductus with a narrower and stronger heart-shaped periostial sclerotization; bursa elongate, the paired, tusk-shaped signa close together near anterior end.

Holotype, male, and two male paratypes, Rio Vermelho, Sta. Catharina, Brazil, A. Mäller; type no. 6816, C.N.C.

Allotype, female, and a number of male and female paratypes, Boraceia, Salesópolis, São Paulo, L. Travassos Filho and F. X. Rabello. Allotype in collection of Ministry of Agriculture, São Paulo, Brazil; paratypes divided between C.N.C. and Ministry of Agriculture, Brazil.

This species closely resembles *P. isoscelalis* (Guenée) in external appearance, but differs radically in the structure of the genitalia, which is intermediate between that of typical *Palpita* and that of the *illibalis* group (*Hapalia* Hübner).

***Palpita travassosi*, new species**

Fig. 9

Frons brown; vertex light buff; palpi fuscous; labial palpus white at base beneath; sides of head and a stripe from head to wing-base fuscous; body pale whitish buff. Forewing above pale translucent buff; costa tinged with brown; a fuscous crescent on discocellular; an obscure brown terminal line, darker at vein ends. Hind wing white, a longitudinal black dash at lower angle of cell; terminal line as on forewing. Wings beneath as above. Expanse 23-27 mm.

Male genitalia. Uncus slender, weakly expanded and dorsally spinose at tip; juxta long and irregular; valve ovate, spinulose on inner surface, a broad, irregular process from distal end of sacculus; penis cylindrical, with a single strong cornutus and a row of small ones.

Female genitalia. Ovipositor and apophyses weak; seventh sternite without a special sclerotization and hardly emarginated posteriorly; dorsal and ventral walls of ostial chamber triangularly sclerotized; ostial end of ductus cylindrically sclerotized, then contorted, leading to a membranous anterior portion; bursa oval, with a pair of thorn-like signa just anterior to the middle.

Holotype, male, allotype, female, and a series of paratypes, Boraceia, Salesópolis, São Paulo, Brazil, 850 m., L. Travassos Filho and F. X. Rabello. Holotype, allotype and some paratypes in collection of Ministry of Agriculture, São Paulo, Brazil; several paratypes, No. 6817, C.N.C.

I take pleasure in naming this species for my generous and patient correspondent Dr. Lauro Travassos Filho, who collected the type series, and who has made it possible for me to study so much valuable material from Brazil.

#### Summary

The following new species and subspecies of *Palpita* are described: *P. kimballi*, Florida; *P. viettei*, West Indies; *P. forficifera*, South America; *P. persimilis*, South America; *P. trifurcata*, Brazil; *P. isoscelalis goubeyrensis*, Guadeloupe; *P. braziliensis*, Brazil; *P. travassosi*, Brazil.

#### Acknowledgments

I am much indebted to the following colleagues for the loan of material: Mr. Harry K. Clench, Carnegie Museum, Pittsburgh, Pa.; Dr. Lauro Travassos Filho, formerly of the Ministry of Agriculture, São Paulo, Brazil; Mr. Pierre E. L. Viette, Museum of Natural History, Paris, France. The authorities of the British Museum (Natural History) permitted me to examine type material in their care, and Mr. E. L. Martin kindly dissected several types for me. The drawings were prepared by Mrs. Marie Spencer.

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### Estimation of Cocoon Populations of the Larch Sawfly, *Pristiphora erichsonii* (Hartig)<sup>1</sup>

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This paper is one in a series on techniques used in estimating populations of various stages of the larch sawfly (Ives, 1955b; Ives and Prentice, 1958). This insect spends most of the year in cocoons in the soil beneath the host tree. The objective of accurate estimation of the cocoon population is to provide a basis for the evaluation of mortality factors affecting this stage. Two methods of estimation are considered in this paper. One is based on soil sampling (Part I) and the other on the number of cocoons formed in traps for falling larvae (Part II).

#### I. SOIL SAMPLES

High intra-plot variability is a characteristic of most soil insect populations. Because of this variability, large samples are required to obtain statistically sound population estimates, and the removal of the insects from these samples requires a large labour force or considerable time.

To reduce variability, Prebble (1943) sampled adjacent squares of soil under the crowns of host trees on successive years to provide an index of the cocoon population of the European spruce sawfly, *Gilpinia hercyniae* (Htg.). Early workers at the Winnipeg Laboratory attempted to adapt this technique to the larch sawfly sampling problem, but the method proved basically unsound for estimating cocoon populations on an areal basis. These workers also noted a very high degree of variability in the distribution of cocoons in the soil and a tendency for the number of cocoons to decrease radially from the trunks of host trees.

<sup>1</sup>Contribution No. 565, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

Other problems in the estimation of larch sawfly cocoon populations from soil samples are: (1) newly-formed cocoons are indistinguishable from cocoons of the previous generation; (2) cocoon formation occurs from mid-July to late August; and (3) mortality factors may begin to destroy cocoons as soon as they are formed.

The inability to distinguish new cocoons limits the sample to cocoons containing living larvae. The samples thus include a small proportion of cocoons from the previous year containing larvae in prolonged diapause and excludes those cocoons of the current year in which the larvae died between cocoon formation and the sampling date. Because the amount of mortality is partially controlled by the duration of exposure, the delay in sampling caused by the long period of cocoon formation affects the results of sampling. The most important mortality factor, small mammal predation, may begin with the earliest cocoon formation, but does not destroy many cocoons before late August. The date providing the best compromise between cocoon formation and mortality is usually about mid-August. The selection of the date requires careful planning to provide data for accurate estimates of the population and comparisons between different areas and years.

During 1957 an intensive study was conducted in the Whiteshell Forest Reserve, Manitoba, to determine if statistically acceptable estimates of larch sawfly cocoon populations could be obtained from soil samples. The investigation covered the distribution of the cocoons in the soil, in relation to crown cover and topography and the estimation of the total cocoon population per unit area. The examination of old cocoons in the samples provided information on mortality factors during the cocoon stage.

#### Methods

The stand in which the study plot was located has been described (Buckner 1957, Plot 3). The plot measured 30 x 66 feet (1/22 acre) and contained 24 tamarack (density 528 per acre). It was divided into a grid with stakes at six-foot intervals. To provide a base for topographical measurements, the tops of these stakes were levelled with the device shown in Fig. 3. This consisted of a chick watering front and 50 feet of rubber hose. The hose was connected to a copper tube soldered over a hole in the fount, and a short piece of glass tubing was inserted in the other end. A jar of water was inverted on the fount on a stand in the middle of the plot. A constant level was obtained from the water in the glass tube after any air was eliminated from the hose. The stakes were driven to the level indicated in the glass tube. A jig was made to fit over the top of the stakes (Fig. 2) and divided the six-foot squares into 36 potential sampling units of one-square foot each, and also provided a guide for measuring (to the nearest half inch) from the level plane to the moss level in the centre of each unit. The plot contained 1,980 potential sampling units, of which 200 were selected at random. One-square foot samples of soil extending down to the limnic peat (the sampling units) were removed from August 21 to 23 from each randomly designated position and placed in plastic bags. Crown projections were mapped with the instrument described by Turnock and Ives (1957).

The 200 sample units were randomly separated into two equal groups. One group was sorted at the Whiteshell Field Station before September 10, and the other by Forest Biology Rangers at the Winnipeg Laboratory after October 1. The soil in each sample unit was carefully teased apart and all cocoons removed. This work had to be done by hand because the fibrous peat making up the soil could not be sifted. A check on the accuracy of the sorters was made by re-examining a portion of the samples.



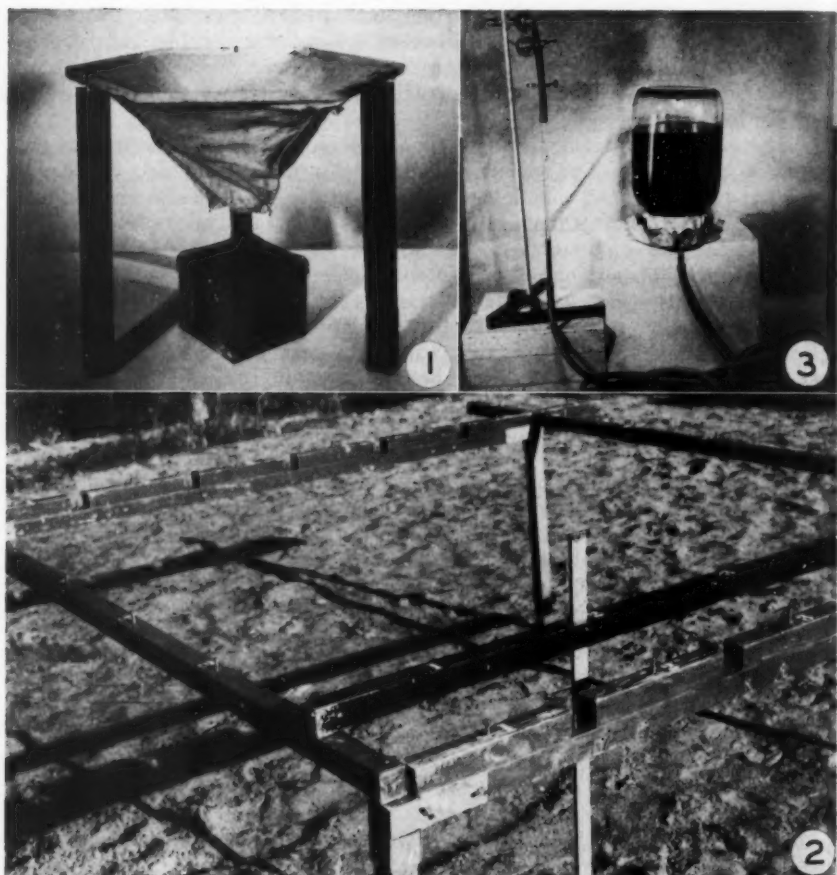


Fig. 1-3.—Apparatus used in connection with studies on sampling for cocoons of the larch sawfly. Fig. 1.—Trap for catching falling larvae. Fig. 2.—Jig for making topographical measurements. Fig. 3.—Apparatus for levelling tops of stakes.

The cocoons in each sample were examined and all apparently sound cocoons were opened. Cocoons containing living larvae were classified as 'sound'. The remainder, called "old cocoons", were classified into four groups: sawfly emerged; dead; killed by the tachinid parasite *Bessa harveyi* (Tnsd.); and eaten by small-mammal predators. The dead group included mortality attributable to the parasite *Mesoleius tenthedinis* (Morley), various insect predators, and disease organisms.

### Results

#### *Bases for stratification of the sample*

The presence of openings in the canopy and the tendency for the number of cocoons per unit area to decrease from the trunk to the periphery of host trees suggested the use of strata based on crown cover. The stratification was based on the position of the sampling unit in relation to tree crowns. The



TABLE I.

Distribution of mean number of cocoons per sampling unit in relation to crown cover and topography.

Crown cover	Cocoon classification	Topographic classification						
		0 - 6.5	7.0-10.0	10.5-13.5	14.0-17.0	17.5-20.5	21.0-27.5	Totals
Under crown	Number of samples	3	5	5	4	1	0	18
	Sound cocoons	38.0	33.0	34.0	35.5	15.0	-	33.7
	Old cocoons	250.7	185.0	149.8	144.0	70.0	-	170.7
Edge of crown	Number of samples	4	17	26	15	15	8	85
	Sound cocoons	17.8	22.3	20.2	27.3	15.5	15.4	20.5
	Old cocoons	173.5	161.6	133.6	120.9	54.8	77.1	120.3
6"-24" from crown	Number of samples	1	9	22	16	12	6	66
	Sound cocoons	18.0	11.1	12.9	19.1	9.9	8.8	11.1
	Old cocoons	182.0	120.5	83.8	84.9	30.1	29.3	75.8
Over 24" from crown	Number of samples	0	6	12	4	6	3	31
	Sound cocoons	-	7.0	9.0	6.0	7.5	4.3	7.5
	Old cocoons	-	63.3	77.9	66.8	32.8	12.7	58.6
Totals	Number of samples	8	37	65	39	34	17	200
	Sound cocoons	25.4	18.5	16.7	18.9	12.1	11.1	16.6
	Old cocoons	203.5	138.9	107.7	102.9	44.3	48.9	100.6

shortest distances from the edges of the sample units to the crown projections were used in grouping the sample units into four categories:

- (1) Under crown—at least six inches within crown projection;
- (2) Edge of crown—less than six inches within crown to less than six inches beyond crown;
- (3) Outside crown I—six to 24 inches from crown;
- (4) Outside crown II—more than two feet from crown.

The distance in inches below the highest location recorded in the topographic mapping was also used to group the sample units as follows: 0-6.5; 7.0-10.0; 10.5-13.5; 14.0-17.0; 17.5-20.5; 21.0-27.5. The first and last groupings are larger because few samples fell into the extreme measurement classes. The results are recorded in Table I. The effect of crown cover and topography on the number of sound cocoons, using separate F tests, was as follows:

Source	Topographical effect			Source	Crown cover effect		
	d.f.	M.S.	F		d.f.	M.S.	F
Topography	5	431.28	3.17	Crown cover	3	3692.71	41.37
Error	194	136.17		Error	196	89.26	

These figures show that both factors contribute to significant differences in the number of cocoons per sampling unit. Similar results were obtained with old cocoons, the F values for topography and crown cover being 20.77 and 22.37, respectively.

The effect of topography on the numbers of sound cocoons was not as marked as for the old cocoons. In both groups the largest number of cocoons were found in samples from hummocks and the smallest from depressions but the relative difference between the extreme numbers was much less. Larvae tend to avoid excessively dry or excessively wet locations when spinning cocoons (Ives, 1955a). During periods of moderate or heavy rainfall the hummocks are favourable sites for cocoon formation, while the hollows are relatively unfavourable, because of periodic flooding. During seasons with light rainfall the tops of hummocks are too dry and the depressions approach optimum conditions for cocoon formation. In 1957 the topographical effects were less pronounced because the July precipitation was only 18.6 per cent of the four-year average for 1955 to 1958. The agreement in the distribution of old and new cocoons in relation to crown cover is good. These results indicated that crown cover and topography provide suitable bases for stratification of the sample.

#### *Estimation of cocoon populations*

The grouping of sampling units (on the basis of crown cover and topography) was used for stratification of the sample. Some pooling of the data was required when less than two sample units were taken in a particular category. The number of possible sample units in each stratum was tallied. The estimated number of sound cocoons in the plot, the standard deviation, and the 95 per cent confidence interval for stratified and random sampling were:

Type of sampling	Numbers of sound cocoons	Standard deviation	95% confidence interval*
Stratified . . . . .	33764	1299.96	$31216 < \mu < 36312$
Random . . . . .	32828	1586.43	$29719 < \mu < 35937$

\*Student's *t* with infinite degrees of freedom is used throughout this paper except where otherwise indicated.

Stratified sampling reduced the variance (and hence the required sample size for a given degree of accuracy) by 32.8 per cent. It reduced the standard deviation (and the width of the confidence interval) by 19.3 per cent. Either stratified or random sampling gives statistically satisfactory estimates with a sample size of 200.

Data on the relative magnitudes of the number of old cocoons probably give a better evaluation of average conditions than a single year's data. The estimated number of old cocoons, the standard deviation, and the 95 per cent confidence interval for stratified and random sampling were:

Type of sampling	Number of old cocoons	Standard deviation	95% confidence interval
Stratified . . . . .	202271	6368.70	$189788 < \mu < 214754$
Random . . . . .	199188	8667.53	$182200 < \mu < 216176$

The effects of stratification were greater for old cocoons than for sound cocoons. Stratification reduced the variance by 46.0 per cent and the standard deviation by 26.5 per cent. The average gain in efficiency obtained by stratification would be larger than obtained for sound cocoons in 1957.

*Required sample size* — By assuming that the variances for the different strata would remain constant at various levels of sampling intensity it is possible to

TABLE II.

Comparison of estimated accuracy obtainable with different sample sizes using simple random sampling and stratified sampling with proportional allocation.

Sample Size	Stratified sampling		Random sampling	
	Standard deviation	$\frac{100  d }{\mu}$	Standard deviation	$\frac{100  d }{\mu}$
Sound cocoons				
50	2656	15.4	3346	19.4
100	2064	12.0	2366	13.7
150	1530	8.9	1932	11.2
200	1300	7.5	1586	9.2
Old cocoons				
50	13347	12.9	18283	17.7
100	9197	8.9	12928	12.5
150	7593	7.4	10556	10.2
200	6369	6.2	8668	8.4

\*The sample of 200 is as sampling occurred, and is not strictly proportional. Calculations for standard deviation ignored the finite correction with the exception of the sample of 200. The half confidence intervals  $|d|$  were calculated for the 95 per cent confidence level based on Student's  $t$  for infinite degrees of freedom, and are expressed as percentages of the stratified estimate of the total sound or old cocoons, referred to as  $\mu$ .

calculate the approximate degree of accuracy obtainable with samples of specified sizes (Table II). The stratified sample estimate of the total was used in these calculations as the best estimate of the true total. The estimated degree of accuracy is fairly good, even for samples of 50. However, these are only approximations, and there is a tendency to overestimate the accuracy of the smaller samples, because the calculations were based on Student's  $t$  with infinite degrees of freedom. Furthermore, there will be considerable sampling variation in the estimates of the total number of cocoons and its standard deviation when small samples are used. Samples of 100, using stratified sampling with proportional allocation, would probably be satisfactory for estimates of cocoon populations.

#### *Recovery of cocoons from sampling units*

The cocoons missed during sorting are a source of error in soil sampling. This error can be particularly serious in large series of sample units because the work is tedious and some workers may become bored and careless after a few days. This effect was overcome to some extent by a careful system of checks, but these were very time consuming.

In the present study the moss was sorted by two groups of workers. It was considered advisable to compare the numbers of cocoons recovered by each group. The crown cover grouping was retained to provide a basis for comparing the relative accuracies at different cocoon densities. The mean numbers of sound and old cocoons recovered by each group of workers were:

Worker group	Under crown		Edge of crown		Outside crown I		Outside crown II	
	Sound	Old	Sound	Old	Sound	Old	Sound	Old
I	41.6	213.6	20.3	130.6	11.4	82.4	6.0	57.0
II	28.6	143.4	20.8	105.5	10.9	69.2	8.1	58.9

The differences in the numbers of sound and old cocoons recovered by the two groups of workers for each crown cover classification were tested by analyses of

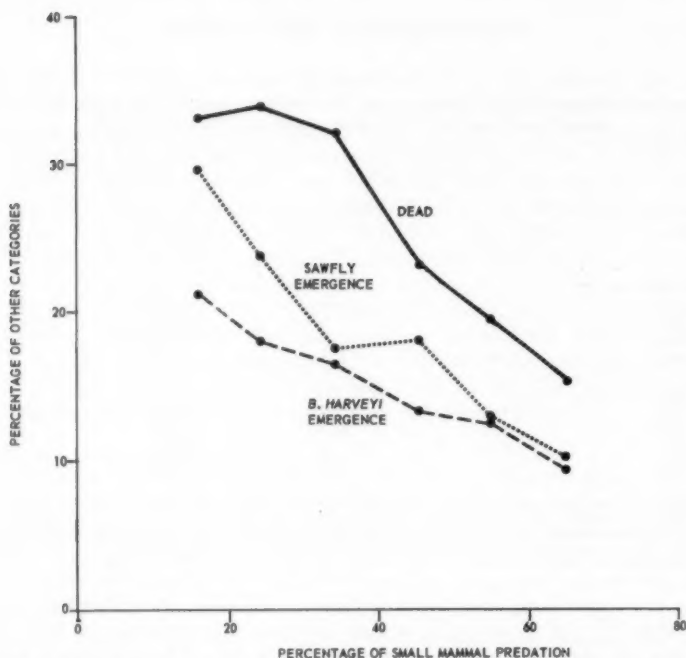


Fig. 4.—Percentages of larch sawfly cocoons showing emergence of sawfly adults, emergence of *B. harveyi*, and dead in relation to percentage predation by small mammals.

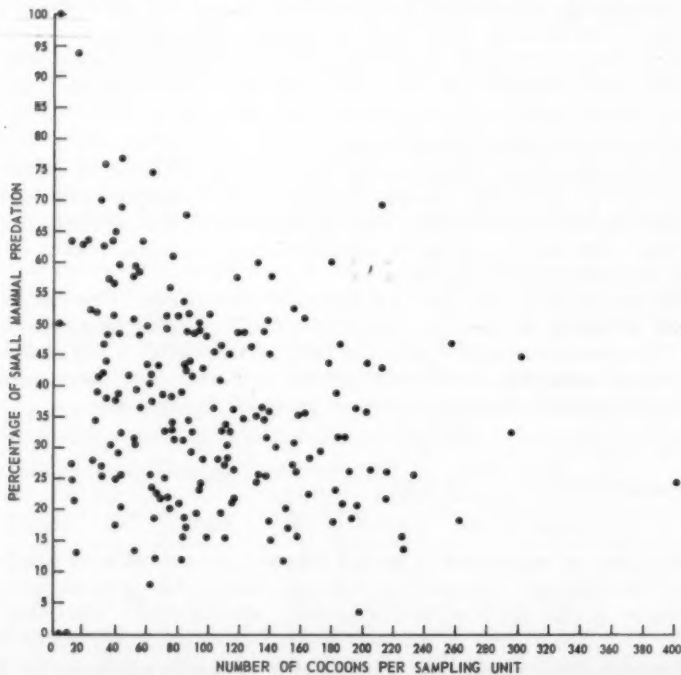


Fig. 5.—Numbers of old cocoons of the larch sawfly per sampling unit in relation to percentages of predation by small mammals.

variance. There were no significant differences in the numbers of sound cocoons found by the two groups in any of the crown cover classifications. The number of old cocoons differed (at the .05 level) for the 'under crown' group.

Another check was provided by the re-examination of 57 sampling units. Only 18 sound cocoons (2.0 per cent of the total) were found in the check sorting. The level of accuracy in the first sorting was concluded to have been satisfactory.

#### *Survival and mortality as estimated from old cocoons*

Estimates of survival and mortality based on examination of old cocoons may be subject to errors arising from differential decomposition rates for various locations. However, these estimates provide information on the long-term effects of these factors under natural conditions.

Adult emergence and mortality data for the different crown cover and topographic groupings are shown in Table III. The only trend indicated is a possible inter-relationship between small-mammal predation and the other three factors. To examine this relationship the data were grouped according to the percentage of small mammal predation. The percentages of sawfly emergence, *B. harveyi* emergence, dead, and small-mammal predation for the grouped data are shown in Fig. 4.

Increased small-mammal predation was associated with decreases in the adult emergence, *B. harveyi* emergence, and dead classes. The decrease in the other mortality factors indicates overlapping between them and small-mammal predation. The predators apparently do not avoid cocoons containing larvae parasitized by *B. harveyi*. The principal small-mammal predator in the plot was *Sorex arcticus laricorum* Jackson, which does not discriminate against cocoons containing larvae parasitized by *B. harveyi* (Buckner, 1958). The decrease in *B. harveyi* emergence was not as great as in sawfly emergence, probably because some of these parasites emerge from the cocoons in the fall before predation occurs. Small mammals also apparently open cocoons containing dead or diseased larvae. However, predation begins in late summer (Buckner, 1953) and some of these larvae might have been alive when eaten but would later have died from other causes. Small-mammal predation is an important mortality factor affecting larch-sawfly cocoons but if "dead" as well as healthy larvae are eaten the impact on sawfly populations is less than if only healthy larvae are eaten.

Although there was apparently no relationship between topography or crown cover and the amount of small-mammal predation, cocoon density could influence the amount of predation. The numbers of old cocoons per sampling unit were plotted against the percentages of small mammal predation to determine if the two were related (Fig. 5). The results clearly indicate that predation was not related to density, and local concentrations of cocoons had little or no baiting effect.

## II. TRAPPING FALLING LARVAE

The inherent weaknesses and large labour requirements of the soil-sampling method led to the consideration of an alternative technique for estimating the number of larch-sawfly cocoons formed per generation. The mature larvae fall freely from the host trees when feeding is completed. The larvae falling on a standard area were channelled into a box containing a suitable cocooning medium (moist sphagnum moss).

This method had the following advantages: (1) The prolonged larval drop period is of no consequence, since the sampling units can be left out until larval drop is finished; (2) Only cocoons formed by the current generation are sampled; (3) Small-mammal predation does not affect the estimate; and (4) The labour

TABLE III.  
Percentage distribution of cocoon classifications within each crown cover and topographic category.

Crown cover	Cocoon classification	Topographic classification						Totals
		0-6.5	7.0-10.0	10.5-13.5	14.5-17.0	17.5-20.5	21.0-22.5	
Under crown	<i>Bessa</i> emerged	12.4	17.6	16.2	17.0	11.4	—	15.7
	Sawfly emerged	18.6	21.3	16.4	16.0	20.0	—	18.4
	Eaten by small mammals	37.8	26.4	32.8	36.6	38.6	—	32.9
	Dead	31.2	34.7	34.6	20.4	30.0	—	33.0
Edge of crown	<i>Bessa</i> emerged	15.0	15.8	17.3	20.6	17.1	11.3	17.0
	Sawfly emerged	20.6	24.4	24.5	18.4	16.6	14.3	21.8
	Eaten by small mammals	40.2	28.6	31.0	26.5	38.2	50.6	32.0
	Dead	24.2	31.2	37.2	34.5	28.1	23.8	29.2
6"-24" from crown	<i>Bessa</i> emerged	11.5	15.6	17.2	16.1	11.9	9.7	15.7
	Sawfly emerged	23.1	19.2	21.3	15.5	17.7	8.0	18.6
	Eaten by small mammals	23.1	28.2	37.7	45.4	36.9	52.3	37.6
	Dead	42.3	37.0	23.8	23.0	34.4	30.0	28.1
Over 24" from crown	<i>Bessa</i> emerged	—	16.3	16.6	11.2	17.8	13.2	15.8
	Sawfly emerged	—	21.6	22.8	12.7	16.8	15.8	20.3
	Eaten by small mammals	—	43.2	34.5	54.7	42.1	50.0	40.4
	Dead	—	18.9	36.1	21.4	23.3	21.0	23.5
Totals	<i>Bessa</i> emerged	13.4	16.1	17.1	18.0	15.7	11.1	16.4
	Sawfly emerged	20.0	22.5	22.6	16.7	17.1	13.0	20.4
	Eaten by small mammals	37.2	29.2	33.5	36.2	38.2	50.9	34.3
	Dead	29.4	32.2	26.8	29.1	29.0	25.0	28.9

required to separate the cocoons from the moss is greatly reduced. The method includes one source of error that may lead to over-estimation of the population. In the sampling units all mature larvae can form cocoons whereas under natural conditions some of them may fail to spin cocoons because of predation or drowning in open pools. Predation was not considered to be an important factor because the larvae quickly enter the ground and in the study area the water table was low so that no drowning occurred.

#### Methods

The sampling unit chosen (Fig. 1) was a funnel with a collecting area of two square feet that delivered the mature larvae into a six-inch-square metal box. This box had a screen bottom and the upper rim was incurved to prevent larvae from escaping. The sampling units were placed in the host stand in mid-June and removed after the larval drop was finished. The larval trap technique was tested for three years in one plot and one year in another.

Both study plots were situated in a pure tamarack stand in the Whiteshell Forest Reserve, Manitoba. Plot I measured 2 x 2.5 chains or 0.5 acres. This area was divided into four annual sampling units of 0.5 x 2.5 chains composed of five 0.5 x 0.5 chain-subplots. The annual change in the sampling area within the plot was necessary because the ground vegetation in the bog forest deteriorated rapidly with trampling. The stand density and populations of larch sawfly in 1956, 1957, and 1958 were tested by analysis of variance and no significant differences between subplots could be detected.

Plot II was located about 100 yards east of Plot I and measured 2 x 2.25 chains (0.45 acres). The stand was similar but the trees were more widely spaced than in Plot I. This plot was sampled only in 1957.



To obtain a random distribution of the sampling units, each plot was divided into numbered two-square-foot units and the required samples drawn at random. In Plot I each of the five subplots sampled annually contained 544.5 possible sample areas, of which 20 were selected. In 1957 a crown-cover map was made of four of the subplots. Plot II contained 10,178 possible sampling areas, of which 100 were selected. This plot was also mapped for crown cover.

#### *Bases for stratification*

With soil samples, stratification on the basis of crown cover reduced the variance of the estimated cocoon populations. It seemed logical to test this basis for stratifying larval trap samples. In Plot II the classification of the sampling areas was based on the distance from the centre of the sampling unit to the nearest crown periphery. The distances from the crown periphery to the centres of the larval traps in each of the eight categories of crown cover were:

##### *Under Crown*

1. more than 17 inches
2. from nine to 17 inches

##### *Edge of Crown*

3. from eight inches under to eight inches outside

##### *Outside Crown*

4. from nine to 17 inches
5. from 18 to 26 inches
6. from 27 to 35 inches
7. from 36 to 44 inches
8. more than 44 inches.

The effect of classification on the basis of crown cover was tested by analysis of variance. The differences between classes were highly significant ( $F=5.17$  with seven and 92 degrees of freedom).

Stratification was also tested with data collected in 1957 from Plot I. The classification of the sampling areas on the basis of crown cover resembled that for Plot II but the number of categories was reduced to 'Under', 'Edge' and 'Outside' of crown. This broader classification was used because the tree crowns and crown openings were smaller than in Plot II. Classification on the basis of subplots, and on crown cover were tested with separate analyses of variance. Neither classification gave significant F values.

These results indicate that stratification on the basis of crown cover increases accuracy only in stands with large openings in the crown cover.

#### *Estimation of cocoon populations*

Estimates of cocoon populations were based on the number of cocoons found in each sample unit after the larval drop was complete. Because the differences between crown cover categories were significant in Plot II, the efficiency of stratification on this basis was compared with random sampling for the estimation of the total cocoon population.

The estimated cocoon population and the standard deviation for the 0.45 acre plot, based on both random and stratified sampling are given below:

Type of sampling	Number of cocoons	Standard deviation	95% confidence interval
Stratified . . . . .	282,340	20,619	$241,927 < \mu < 322,753$
Random . . . . .	292,210	22,467	$248,174 < \mu < 336,246$

Stratification reduced the standard deviation by 8.23 per cent. This increase in efficiency is too small to justify the use of stratification in pure tamarack stands. In stands containing tree species other than tamarack or in open stands of tamarack, a stratification based on crown cover might be necessary to give the required degree of accuracy in estimating the total cocoon population.

Random sampling appeared to be a satisfactory method for estimating populations. In Plot I three years' sampling data were analysed to give the estimated population per 0.125 acre plot shown below:

Year	Degrees of freedom	Number of cocoons	Standard deviation	95% confidence interval
1956	99	98,527	4559	$89,487 < \mu < 107,567$
1957	99	118,510	6360	$105,898 < \mu < 131,122$
1958	49*	51,445	4024	$43,360 < \mu < 59,530$

\*Only 50 sample units were available because 50 were overwintered in the plots.

Statistically these population estimates were satisfactory. In 1956 and 1957, with 100 sample units, the  $\frac{1}{2}$  - 95 per cent confidence intervals were 9.2 and 10.6 per cent of the respective means. In 1958, with only 50 sample units, this percentage rose to 15.7.

Population estimates based on the larval trap method are larger than those made from soil samples. In Plot I both types of sampling were conducted in 1956 and 1957. Each year 50 one-square-foot soil samples were collected at random with 10 samples per subplot. The estimates of cocoon populations per acre for the two years, based on soil samples and larval traps were:

Type of sampling	n	Number of cocoons	Standard deviation
1956			
Soil.....	50	77,646	6720
Larval traps.....	100	98,527	4559
1957			
Soil.....	50	87,664	7484
Larval traps.....	100	118,510	6360

The difference between the two estimates was 21.2 per cent of the larger number in 1956 and 26.0 per cent in 1957. This emphasizes that the two methods do not estimate the same population. Soil samples provide estimates of the number of cocoons containing living larvae, while larval traps estimate the total number of cocoons formed.

The data presented in this paper lead to the conclusion that larval traps are the most practical method of estimating the larch sawfly cocoon population. In addition, estimates based on this method provide the most promising basis for evaluating mortality. A subsequent paper will discuss methods of evaluating mortality factors using the larval trap technique.

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## The Gypsy Moth and Some Possibilities of the Control of Insects by Genetical Means

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The screw worm, *Callitroga hominivorax* (Coquerel), can be sterilized by irradiation in such a way that the viability and sexual behaviour of the male are not seriously affected by the treatment. If such flies are released into a wild population, many of the males will mate with the native females which, since they mate only once, will become permanently infertile. Thus in proportion to the numbers released the numbers of fertile egg-masses produced by the population will be reduced; and if the numbers released are sufficient the population, failing rapid and extensive relief from a density-dependent controlling factor, could be eradicated in a few generations. This eradication has in fact been achieved on the island of Curacao; and the prognosis for the much larger undertaking now in progress in Florida is very favourable (see Lindquist and Knipling, 1957, for discussion and references).

It is obviously essential that the dosage of radiation required for sterilizing the insect should not seriously affect its ability to survive and mate. In the screw worm, fortunately, this condition is realized; but there seems to be no reason to suppose that it will be in every case.

Certain insects can probably be controlled or eradicated by a somewhat similar method that does not depend on artificial sterilization. For *Porthetria dispar* (L.), the gypsy moth, almost all the necessary basic information was obtained by Goldschmidt in his classical researches on sex-determination and geographic variation (summary in Goldschmidt, 1934), but the relevance of the facts to the problems of economic entomology does not seem to have been recognised.

In the gypsy moth, as in other Lepidoptera, the female is the heterogametic sex; the male determining factors lie in the X-chromosome while the female determining factors are conceived of as cytoplasmic. (The interpretation and terminology of Goldschmidt's review of 1934 will be used; other interpretations are possible but there is agreement as to the facts.) The species ranges from western Europe to Japan, and exists in a number of geographical races many of

which differ in, among other things, the 'potency' of the sex-determining factors. In any particular race the male and female determining factors are balanced against one another in such a way that the male determinant in one X-chromosome together with the female determinant control a development leading to a normal female, whereas two male determinants in the same environment lead to a normal male. The sex-determinants, however, though so balanced in any normal, intraracial mating, vary quantitatively so that a single X-chromosome of a 'strong' race will preponderate over the female determinant of a 'weak' race and lead to the development not of a female but of a female-male intermediate (intersex) or even, in crosses between the most widely differentiated races, of a male. The 'strong' races are found in eastern Asia and in particular are characteristic of the northern and central regions of the Japanese island of Honshu; the European races range from 'ultra weak' through 'weak' to 'half weak'.

The gypsy moths established in North America came from France and belong to a half weak race. If a female is crossed with a male of a strong race, the male progeny will be normal and fertile while the female progeny will be middle grade intersexes and sterile. Thus the practical proposal, in its simplest form, is to rear one of the strong races in very large numbers and in such a way as to synchronise the emergence with that of the established population; and to liberate the males, alone. The females with which these males mated—in *Porthetria dispar*, again, the female is believed to mate once only—would produce a generation of offspring in which all the females were intersexual and sterile. Liberation of the strong males would continue for several generations, until the population was eradicated.

There is, as before, an essential condition; namely that the foreign males will effectively discover and mate with the established females, of a different race. In the laboratory the hybridization of the races of gypsy moth evidently presents little difficulty; and Goldschmidt records that heterozygotes occur in the border zone between the strong and neutral sex races in central Honshu. Nevertheless, it may well be impossible to obtain assurance of this point to a sufficient degree except by a trial liberation. If this doubt can be resolved favourably the chief remaining problem is the practical one of rearing the insects in sufficient numbers and at the appropriate time.

The hybrid females will, as already noted, be intersexual and sterile. There is, of course, a certain range of variation, but the middle grade of intersexuality, characteristic of the offspring of a strong male and a half weak female, seems always to involve complete sterility, and the insect, though tending to a female type of behaviour, rarely attracts a male.

The males will be fertile and able to breed with surviving native females; since they are heterozygotes for potency of the sex-determinants they will yield progeny in which one half of the females will again be intersexual. They might therefore assist in some measure the progress towards eradication, although the liberation of strong males would be continued. They would at the same time be transmitting other genetic factors of the Japanese race, in various assortments, to the American stock; thus there is a risk that a new and more successful form might emerge. This risk could be guarded against, to some extent, by testing the progeny of experimental crosses before liberation is attempted, just as the potentialities of an introduced phytophagous insect are explored before it is liberated as a weed control agent. The process, moreover, would have to take effect within a population already on the decline; and the new form, however successful, would carry the half weak sex-determinants and would still be susceptible to control by the introduction of strong males.

It would probably be easy to separate the sexes of the gypsy moth either by the weight of the full grown larvae or the pupae, or by the sedentary habits of the female and the ready flight of the male; the great difference in colour would provide a simple check. If however the form to be liberated was unlikely to establish itself in the new environment then perhaps both sexes might be released. It is assumed that the males will mate several times.

Generalizing from this example, it may be noted first that the production of intersexual progeny is not of the essence; it is sufficient that the crossing of two forms that are not sexually isolated should, immediately or ultimately, be unfruitful. Nevertheless, the occurrence of intersexuality among the offspring of interracial and interspecific crosses is a recurring and perhaps even typical phenomenon.

It is difficult to estimate how frequent such reproductively but not sexually isolated forms may be. Mayr (1942) has pointed out that there is no evident reason that reproductive and sexual isolation should develop concurrently in geographically isolated forms; only when two reproductively isolated forms later become sympatric would it be of advantage to have a barrier to mating also. Instances in which inter-sterile geographical races or closely related species mate fairly readily in the laboratory are not uncommon; and again, there are important elements in the mating process, such as the response of the male mosquito to the flight tone of the female, which are non-specific both in the laboratory and in nature (Downes, 1958). Nevertheless such observations may not be borne out in the field or may relate merely to a part of a necessary chain of events. It is difficult therefore to select candidate species from the literature with any assurance. There is however a very interesting example in the tsetse flies *Glossina morsitans* Westwood and *G. swynnertoni* Austen. On crossing, these largely allopatric species yield only a few offspring, mostly sterile; yet both in the laboratory and in nature mating seems to be at random (Vanderplank, 1947). It was suggested that *G. swynnertoni* could be eliminated, at least when it had been reduced to a low level by other means, by massive introductions of *G. morsitans* into its territory. An experiment was set up and the early results were said to be favourable, but the final outcome is not known.

It is possible also to look beyond parallels to the case of the gypsy moth as considered above and to envisage certain refinements. To test his theory of the location of the sex-determinants in the cell, Goldschmidt built up a series of complex crosses and showed that whatever the origin of the autosomes the potency of the sex-determinants remained unaffected. Thus, in certain species at least, it should be possible to build up a form virtually identical with the race to be controlled except in regard to the sex-determinants, derived from the incompatible foreign race. If this form was used in the releases the probability of normally successful mate-finding would be increased and the danger of establishing a new and successful hybrid would be reduced.

It has already been noted that the first generation of hybrid males are heterozygotes, and will in their turn cause one half of their female offspring to be intersexual. The strong X-chromosome has however a steady tendency to become extinct (since those transmitted to female offspring cause sterility and are eliminated) unless it is favoured by selection. It would be highly pertinent therefore to investigate whether the strong sex-determinant could not in some way be associated with a selective advantage. There are also a few genes known to have an inherent tendency to increase, a tendency that may however be counterbalanced by selection (Wallace, 1948). There seem, therefore, to be



reasonable grounds for hoping that it might become unnecessary to make the massive and repeated introductions envisaged in the simple proposal. Presumably however this end would be achieved only as a result of a thorough study of the sex-determination, and perhaps of the behaviour and ecology also, of each species under consideration.

I wish to acknowledge my debt, for advice and encouragement, to several friends and colleagues; in the first place to Dr. G. W. K. Stehr, Forest Biology Laboratory, Sault Ste. Marie, Ontario, and also to Mr. W. J. Brown, Dr. L. Davies, Dr. E. F. Knipling, Dr. E. G. Munroe, Dr. B. N. Smallman and Dr. A. Wilkes.

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### The Pales Weevil, *Hylobius pales* (Hbst.), in Southern Ontario<sup>1</sup>

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#### Introduction

The pales weevil, *Hylobius pales*, was described in 1797 by Herbst (9), but it was not until 1916 that its importance in limiting the regeneration of white pine, *Pinus strobus* L., in cut-over areas was established by Carter (4). He reported that up to 70 per cent of young reproduction trees might be killed by adults feeding on the bark of young seedlings during the first two years following clear cutting of white pine. He concluded that it was unwise to plant white pine during the two seasons following cutting because seedlings in the vicinity of the stumps, in which the weevil breeds, would be subjected to heavy feeding, and the resulting loss of trees would produce open areas in the planting. In 1921, Peirson (10) recorded in broad terms the seasonal history, distribution, host plants, habits, and control of the weevil, based primarily on a study of the insect in Massachusetts. More recently, Beal and McClintick (1), Bess (2), Savely (11), Sentell (12), and Wells (16) have emphasized the continued importance of the weevil as a forest pest and have recorded its presence in most of the United States east of the Mississippi and north of Florida, and in Canada from Nova Scotia to Manitoba. Friend and Chamberlin (8) and Ebel and Speers (5) have discussed population levels of the weevil in relation to cutting practices, and Speers (13, 14, 15) has discussed its control through the use of sprays and dips.

Although considerable attention has been given to the pales weevil as a pest of young pine regeneration in the New England and southeastern States of the United States, little has been published on its occurrence in the Lake States or southern Ontario where it is more closely associated with trees in plantations, particularly of Christmas trees. In Christmas-tree plantations, there is a more or

<sup>1</sup>Contribution No. 566, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada. Based on part of a thesis submitted as partial fulfilment for the degree of Doctor of Philosophy at the University of British Columbia.



less continuous supply of breeding material once harvesting of trees has commenced, and the bionomics of the insect has not been well known under these conditions.

In southern Ontario the pales weevil has, during recent years, assumed a position of some importance as a member of a complex of weevils associated with pines grown in reforestation projects and Christmas-tree plantations. In addition to the pales weevil, the complex includes the pine root collar weevil, *H. radialis* Buch., the northern pine weevil, *Pissodes approximatus* Hopk., and the strawberry root weevil, *Brachyrhinus ovatus* (Lec.). An investigation of the complex was undertaken in 1955 and continued in subsequent years from a field laboratory at Angus in Simcoe County. Field observations were made in a number of widely separated plantations of mixed white pine, red pine (*P. resinosa* Ait.), jack pine (*P. banksiana* Lamb.), and Scots pine (*P. sylvestris* L.), and in seedling beds in the Provincial Tree Nursery at Midhurst. The seasonal history and habits of the northern pine weevil, *P. approximatus* in southern Ontario have already been described (7).

#### Hosts

In the United States *H. pales* adults have been reported feeding on a wide range of conifers including *Pinus*, *Abies*, *Larix*, *Picea*, *Tsuga*, *Pseudotsuga*, *Juniperus*, *Cupressus*, and *Cedrus*, as well as on *Betula* and *Fraxinus*. However, Carter (4), Peirson (10), and Friend and Chamberlin (8) agree that white pine is the preferred food plant. In southern Ontario the weevil has been found feeding on white pine, red pine, jack pine, Austrian pine (*P. nigra* Arn.), Scots pine, and tamarack (*Larix laricina* (Du Roi) K. Koch). Although feeding occurs on the branches of large trees, the trees suffer little or no damage after they have reached a height of about ten feet.

It has not been clearly stated, however, in what plants the weevil breeds. Several authors refer to pines and spruces as suitable breeding material (4, 8, 10, 16), but only white pine, pitch pine (*P. rigida* Mill.), ponderosa pine (*P. ponderosa* Laws.), mugho pine (*P. mugho* Turra.), and cembra pine (*P. cembroides* Zucc.), have been named specifically as probable hosts of the immature stages (1, 4, 10, 16). In southern Ontario, pales weevil adults were reared from stumps of red, jack, and Scots pine, as well as from white pine.

#### Seasonal History and Habits

According to Peirson (10), in Massachusetts the adults of the pales weevil emerge from hibernation about mid-May and feed until about mid-June, at which time they migrate to an area where there is suitable breeding material. He indicated that oviposition begins about July 1, that the resulting larvae pupate about September 1 to emerge as adults about October 1, and that they feed for two or three weeks before entering hibernation, thus completing one generation per year. Although Peirson did not elaborate the point, he concluded, on the basis of larvae having been found as late as October 8, that some individuals undoubtedly pass the winter in the larval or pupal stage in stumps or logs. Beal and McClintick (1) questioned Peirson's description of the seasonal history, and stated that in North Carolina there is "one complete generation and a partial second overlapping generation annually". In southern Ontario the pales weevil overwinters in both the adult and larval stages (Fig. 1). Approximately 70 per cent of the summer larvae pupate and emerge as adults from late-August to mid-October to overwinter after a short feeding period. The remaining 30 per cent overwinter in the larval stage. Head-capsule measurements of 27 overwintering larvae indicated that they overwinter only in the fifth and sixth instars.

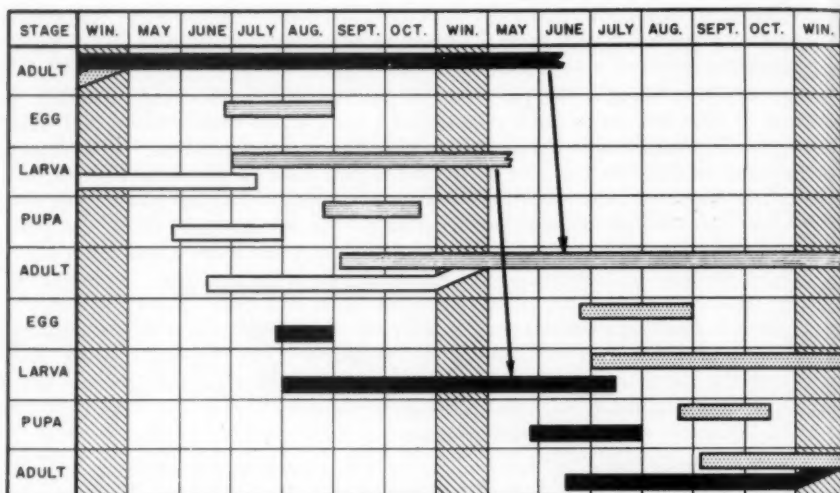


Fig. 1. Seasonal history of *Hylobius pales* in southern Ontario.

These larvae continue development during the following spring and emerge as adults from about mid-June to August 1. Only a few eggs are laid by these adults during the current summer. In the fall the early adults merge with the main adult population to overwinter in the soil, usually at the base of young plants on which they were feeding. The overwintered adults emerge from hibernation in late April and early May and feed for about two months before ovipositing. The eggs are laid in niches chewed in the inner bark of the roots and the part of the stump below ground level. The female lays her eggs erratically, sometimes laying two or three in one day followed by several days of inactivity. The eggs are usually deposited singly, but sometimes two or three are placed together in single niches. The first egg laid in the laboratory in 1958 was on June 12; the general oviposition period lasted until the end of July, although one female laid three viable eggs on August 30 after being inactive for over four weeks. The incubation period is approximately ten days in length. The larval period lasts for about 47 days followed by a pupal period of about 22 days. Table I shows the average duration of each of the instars for both fifth- and sixth-instar larvae, as well as for the egg and pupal stages.

TABLE I.  
The duration of the immature stages of *Hylobius pales*.

Stage	Time (days)
Egg.....	9.9 ± 1.3
1st instar.....	5.3 ± 0.8
2nd instar.....	5.0 ± 0.8
3rd instar.....	5.1 ± 0.7
4th instar.....	6.5 ± 1.0
5th instar (prepupa).....	20.8 ± 2.2
5th instar.....	9.3 ± 1.4
6th instar (prepupa).....	21.3 ± 2.8
Pupa.....	21.8 ± 1.3

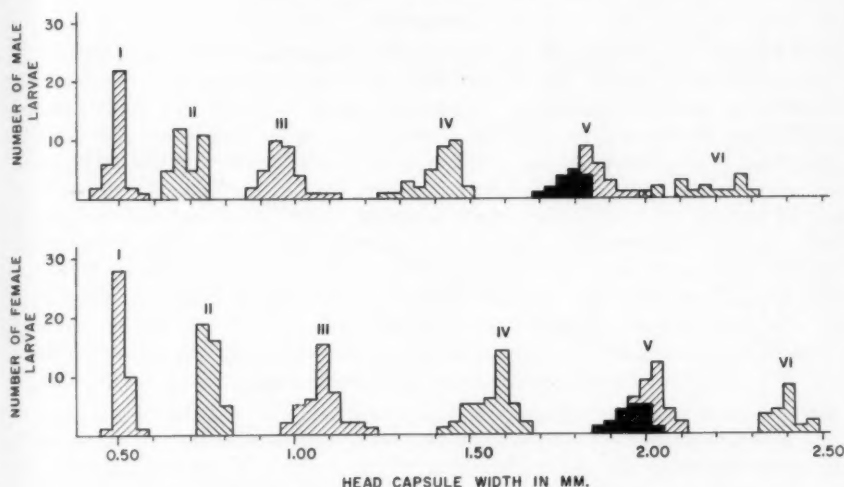


Fig. 2. Distribution of head capsule measurements of 73 *Hylobius pales* larvae reared in the insectary from the egg to the adult. The black area represents the measurements of the fifth instar larvae that continued development to a sixth instar before pupating.

Out of 73 larvae reared in the insectary from egg to adult, 33 were males and 43 were females. Fig. 2 illustrates the distribution of measurements of head capsule widths of these larvae, separated by sex, as they developed through each instar. It can be seen from the graph that 16 males and 18 females completed six instars before pupating, the remainder completing only five.

Simple calculations comparing the ratio of the means of the head capsule widths of successive instars show that this ratio is relatively constant for the first five instars of both males and females, but that between the fifth and sixth instars it increases considerably. Thus the mean width of the sixth instar is closer to the mean of the fifth instar, for each sex, than is indicated by Dyar's rule. The cause of the increase in the ratio becomes evident when the larvae of the sixth instar are traced back to their proper positions in the fifth instar. The shaded areas under the fifth instar in Fig. 2 represents these larvae and they are seen to be the smaller individuals of that instar. Thus the sixth instar larvae are not truly representative of the fifth instar in head capsule width and consequently have a mean width less than is predicted by Dyar's rule. It is of further interest that since the size of the adult is closely related to the size of the prepupa, as shown in Fig. 3, the smaller, usually less vigorous larvae, by continuing their development to a sixth instar before pupating, ultimately produce the larger adults in the weevil population.

The newly hatched larvae feed in the cambial area of the roots or stump, scarring the wood more deeply than the inner bark. The tunnels do not form a definite pattern in the lower part of the stump, but wander without respect to the grain of the wood. In the roots, however, the tunnels always run with the grain. When the larvae reach maturity they construct "chip cocoons" in the wood about one-quarter inch in depth and parallel to the grain. These cells may be found in the part of the stump lying below ground level and throughout

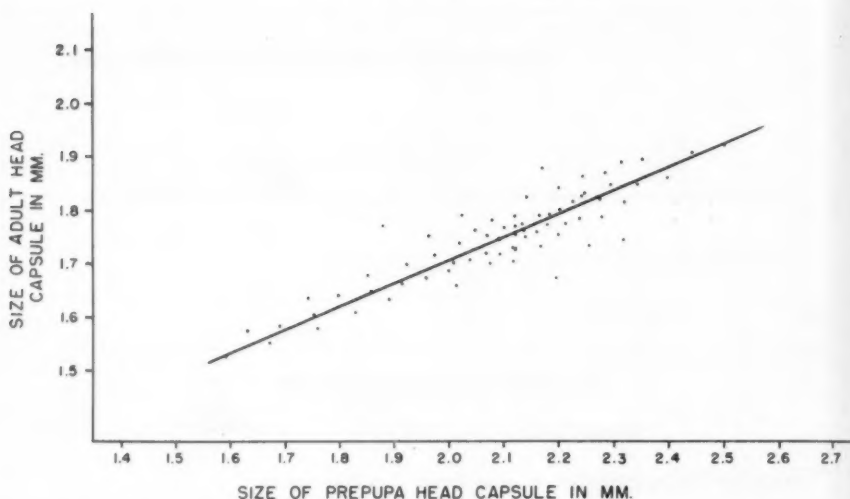


Fig. 3. Relationship between the head capsule size of prepupae and adults of *Hylobius pales*. The regression line  $Y = 0.413X + 0.889$  has been fitted to the data.

the root system where the roots are more than one-quarter inch in diameter. About 70 per cent of the larvae pupate in the roots at a distance greater than one foot from the stump. A few of the pupal cells are made completely within the wood. When the pupal cell is complete the larva encloses itself within it by sealing the entrance with long excelsior-like chips of wood obtained while digging the cell. A short prepupal period of about three days follows, during which the prepupa is inactive.

Rearing experiments showed that adult weevils are long lived; about 35 per cent overwintered twice, the females ovipositing during two successive growing seasons. The females laid about 30 eggs, or 60 per cent of their total quota, during the summer following the first overwintering period as adults, and about 18, or 40 per cent during the second summer. In ten study trees, about 80 per cent of the pales-weevil larvae developed in the roots of the stump, while the remaining 20 per cent developed in the part of the stump below the root collar — in and around the crotches of the main roots.

Bark traps and potted seedlings set up in the field showed that overwintered adults feed and search for breeding material until about the third week in June, and then devote most of their time to egg laying in dead or dying stumps. The feeding damage is light during July and August, but becomes heavy again in mid-September when the new adults begin emerging. There are, therefore, two feeding periods per year — one in the spring and one in the fall. Following a single cutting operation there are three feeding periods on surrounding regeneration before the weevil population subsides, as reported by Peirson (10): the first is in the spring following the cutting, by adults attracted to the freshly cut stumps from the surrounding area; the second is in the fall of the same year after the new adults have emerged from the stumps; and the third is in the following spring by the large adult population that overwintered in the area.

### Discussion

Until recent years, damage to pines caused by the pales weevil has not been as extensive in southern Ontario as reported in the United States, probably because there had been no large-scale cutting operations of pines in southern Ontario for some time, thus preventing a build-up of the weevil population. Since 1945, however, the Christmas-tree industry has expanded greatly and large cutting operations of six-, seven-, and eight-year-old trees have been conducted during the past few years. The stumps of these trees, left in the ground to rot, were heavily infested by the pales weevil and the northern pine weevil, (the adults of which also feed on pine branches), with the result that these weevils now occur in epidemic numbers in Simcoe County and Durham County and generally in the area west of a line drawn through Port Severn and Trenton. In areas where the damage is heaviest, up to 40 per cent of the branches of five- to ten-year-old pines have been killed or discoloured over the whole stand.

Although Peirson (10) and Savely (11) stated that the pales weevil breeds in pine logs as well as in stumps, Beal and McClintock (1) claimed that this was not the case in North Carolina, but that it breeds only in the roots and stump of dying pines. In southern Ontario the adult weevils were attracted to the underside of freshly cut pine logs, but only a few eggs were laid and none of the resulting larvae developed to maturity. This is probably due to the lower moisture content of the logs during dry periods, and partly to competition from immature stages of the northern pine weevil and of *Ips pini* (Say), a bark beetle that attacks freshly cut pine logs in large numbers.

Peirson (10) also stated that there is a mass flight period about mid-June from cut over areas, particularly in the third year of infestation. This habit has not been noted in southern Ontario. It should be remembered, however, that Peirson was referring to weevil populations associated with lumbering operations, and that under these circumstances, when the available breeding material is used up, the adult weevils must migrate of necessity to a new area for breeding purposes. In southern Ontario, on the other hand, the weevil is associated mostly with Christmas-tree plantations where selective cutting is practised and a continuous supply of breeding material is available. Under these conditions it is not necessary for mass migrations to take place.

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### Feeding Sites of Aphids of the Genus *Cinara* Curtis (Homoptera: Aphididae) in Northwestern Ontario<sup>1</sup>

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While working at Cedar Lake in Northwestern Ontario in the summers of 1957 and 1958 the author was able to observe the feeding sites of various species of *Cinara*. Most of the observations were made within an area of a few square miles on either side of Highway 105, between Red Lake Road and Ear Falls, Ontario. This area is fairly typical of the Laurentian Shield, with numerous lakes, rocky ridges, sandy patches, and small bogs. The principal coniferous trees in this locality are black spruce, jack pine, and balsam fir. White spruce, white cedar, white pine, red pine, and common juniper are also present.

The particular feeding sites each aphid occupied on its host tree did not vary significantly from one tree to another, or one locality to another. Although as many as six aphid species occurred on one species of host, with frequently the same individual tree supporting several different species, the aphid populations remained separate, and were found to be intermingled only rarely.

The host trees and feeding sites of the species of *Cinara* present are listed in Table I.

It is hoped that this paper will help to point out the desirability of recording the feeding sites of species collected in the field. In the present confused state of the systematics of species in the genus *Cinara*, information of this kind is invaluable in establishing or confirming the separateness of morphologically similar species.

<sup>1</sup>Contribution No. 562, Division of Forest Biology, Research Branch, Department of Agriculture, Ottawa, Canada.



TABLE I.

Feeding Sites Occupied by *Cinara* Spp. Aphids on their Host Trees.

Species		Time of Year		
<i>Cinara</i>	Host tree	Early spring	Late spring	Summer
<i>C. pergandei</i> (Wilson)	<i>Pinus banksiana</i> Lamb.	twigs <sup>1</sup>	twigs <sup>1</sup> shoots <sup>2</sup>	twigs <sup>1</sup> shoots <sup>2</sup> branches <sup>3</sup>
<i>C. banksiana</i> Pepper and Tissot	"	"	shoots <sup>2</sup>	branches <sup>4</sup> galls <sup>5</sup>
<i>C. canatra</i> Hottes and Bradley	"	branches <sup>4</sup>	branches <sup>4</sup>	branches <sup>4,6</sup> trunk <sup>7</sup>
<i>Cinara</i> sp. 3	"	shoots <sup>8</sup>	shoots <sup>8</sup> needles <sup>9</sup>	shoots <sup>8</sup> needles <sup>9</sup>
<i>C. pinivora</i> (Wilson)	"	branches <sup>10</sup>	branches <sup>10</sup>	branches <sup>10</sup>
<i>C. piniradicis</i> Bradley	"	trunk <sup>11</sup>	roots	roots
<i>C. braggii</i> (Gillette)	<i>Picea glauca</i> (Moench) Voss and <i>P. mariana</i> (Mill.) B.S.P.	twigs <sup>1</sup>	twigs <sup>1</sup> shoots <sup>2</sup>	shoots <sup>2</sup>
<i>C. fornacula</i> Hottes	"	"	twigs <sup>1</sup> shoots <sup>2</sup>	shoots <sup>2</sup>
<i>C. hottesi</i> (Gillette and Palmer)	"	branches <sup>4</sup>	branches <sup>4</sup> trunk <sup>7</sup>	branches <sup>4</sup>
<i>C. palmerae</i> (Gillette)	"	branches <sup>4</sup>	roots	roots
<i>C. coloradensis</i> (Gillette)	<i>Picea glauca</i>	branches <sup>4</sup>	branches <sup>4</sup> trunk <sup>7</sup>	branches <sup>4</sup> trunk <sup>7</sup>
<i>C. laricifex</i> (Fitch)	<i>Larix laricina</i> (Du Roi) K. Koch	twigs <sup>1</sup>	twigs <sup>1</sup> branches <sup>4</sup>	twigs <sup>1</sup> branches <sup>4</sup>
<i>C. spiculosa</i> Bradley	"	"	"	"
<i>C. abieticola</i> (Cholodkovsky)	<i>Abies balsamea</i> (L.) Mill.	twigs <sup>12</sup>	branches <sup>4</sup> trunk <sup>7</sup>	roots
<i>C. curvipes</i> (Patch)	"		branches <sup>4</sup> trunk <sup>11</sup>	trunk <sup>11</sup>
<i>C. strobis</i> (Fitch)	<i>Pinus strobus</i> L.	branches <sup>4</sup>	branches <sup>4,6</sup>	branches <sup>4,6</sup> trunk <sup>7</sup>
<i>C. carolina</i> Tissot	<i>Pinus resinosa</i> Ait.		branches <sup>4</sup>	branches <sup>4</sup>
<i>C. juniperi</i> (De Geer)	<i>Juniperus communis</i> L.	twigs <sup>1</sup>	twigs <sup>1</sup> shoots <sup>2</sup>	shoots <sup>2</sup>

<sup>1</sup>Small one-year-old twigs at the ends of the main branches and in the periphery of the crown.<sup>2</sup>Growing shoots at the ends of the main branches or leader.<sup>3</sup>Lower branches or trunk of open-grown trees two to three feet in height, just above ground level.<sup>4</sup>Two-and three-year-old portions of branches near the periphery of the crown.<sup>5</sup>*Cronartium* galls on main stem just above the ground on small trees three to five feet in height.<sup>6</sup>Large branches  $\frac{3}{4}$ " or more in diameter.<sup>7</sup>Upper trunk of tree up to thirty feet in height.<sup>8</sup>Small, slow-growing shoots from larger branches or upper trunk near the centre of the crown.<sup>9</sup>Needle bundle sheaths and needles of the shoots noted in (<sup>8</sup>).<sup>10</sup>Branches almost bare of needles, often broken stubs close to the ground, at the base of the crown of open-grown trees.<sup>11</sup>Lower trunk of trees up to 5" d.b.h.<sup>12</sup>At tips of twigs noted in (<sup>1</sup>), just below the unopened buds.

(Received June 1, 1959)

**International Commission on Zoological Nomenclature:  
Notice of proposed use of Plenary Powers in certain cases  
(A.(n.s.)42)**

In accordance with a decision of the 13th International Congress of Zoology, 1948, public notice is hereby given of the possible use by the International Commission on Zoological Nomenclature of its plenary powers in connection with the following cases, full details of which will be found in *Bulletin of Zoological Nomenclature*, Vol. 17, Parts 1/2, to be published on 1 October, 1959:

- (1) *Orthoceros* Brünnich, 1771, and *Orthocera* Modeer, 1789, suppression of (Classes Foraminifera and Cephalopoda) (Z.N.(S.)44);
- (2) *Orthoceratites* Lamarck, 1799, suppression of (Class Pelecypoda) (Z.N.(S.)1395);
- (3) *Protobechus* and *Alloneura* Rondani, 1856, suppression of (Class Insecta, Order Diptera) (Z.N.(S.)230);
- (4) *Beraea* Stephens, 1833, designation of type-species (Class Insecta, Order Trichoptera) (Z.N.(S.)395);
- (5) *Apatania* Kolenati, 1847, designation of type-species (Class Insecta, Order Trichoptera) (Z.N.(S.)427);
- (6) *Aphrophora* Germar, 1821, designation of type-species (Class Insecta, Order Hemiptera) (Z.N.(S.)478);
- (7) *Drepanella*, validation of (Class Crustacea, Order Ostracoda) (Z.N.(S.)1112);
- (8) *Westonoceras*, validation of (Class Cephalopoda) (Z.N.(S.)1226);
- (9) *saccharivora* Peterkin, 1790 (*Phalaena*), suppression of (Class Insecta, Order Lepidoptera) (Z.N.(S.)1315);

Any zoologist who wishes to comment on any of the above cases should do so in writing, and in duplicate, as soon as possible, and in any case before 1 March, 1960. Each comment should bear the reference number of the case in question. Comments received early enough will be published in the *Bulletin of Zoological Nomenclature*. Those received too late for publication will, if received before 1 March, 1960, be brought to the attention of the Commission at the time of commencement of voting.

All communications on the above subject should be addressed as follows: The Assistant Secretary, International Commission on Zoological Nomenclature, c/o British Museum (Natural History), Cromwell Road, London, S.W.7. England.

RICHARD V. MELVILLE  
Assistant Secretary  
International Commission on Zoological  
Nomenclature

September, 1959.

